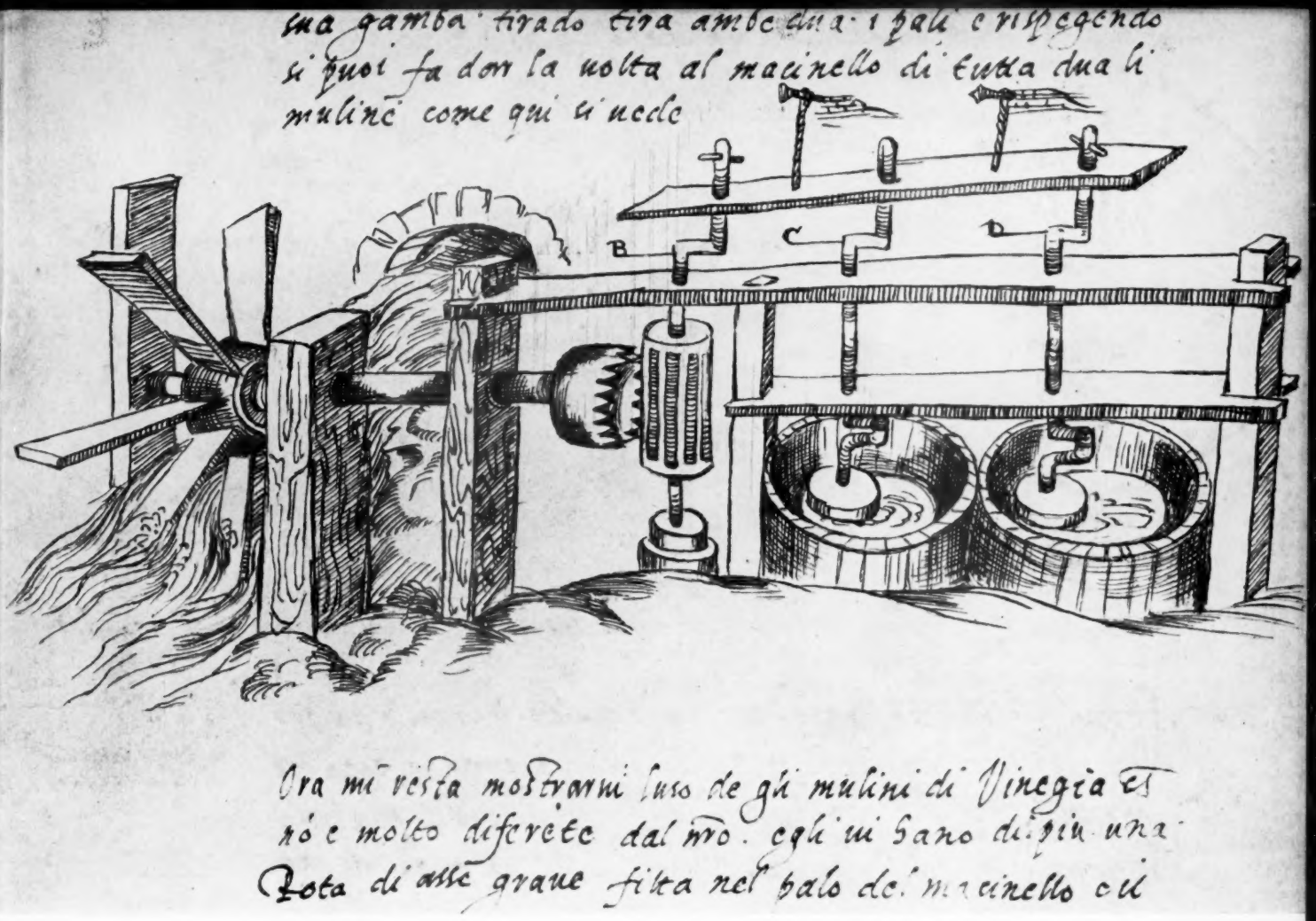
una gamba tirado tira ambe dua i pali e rispegendo
si puoi fa dar la volta al macinello di tutta dua li
mulinē come qui si vede
B
C
D
Ora mi resta mostrarmi luso de gli mulini di Vinegia es
sō e molto diferete dal mio. egli mi sano di gia una
Rota di asse grane fita nel palo del macinello cil

Illustration from Li Tre Libri Dell' Arte Del Vasaio

■ Small pieces of flint or carnelian, arranged in a circular form with a flat top surface and joined with a mixture of lime, sand, and plaster, were set in a wooden tub to form the color-mill used in the time of Cipriano Piccolpasso. The grinding stone, sometimes composed of several pieces bound with an iron ring, was laid above it. The illustration shows a 16th Century color mill run by water power. In Piccolpasso's words, "It is very admirable for this operation [*i.e.*, grinding of ceramic colors] because it distills the colours, and the better these are ground the more use they are, the more economical, and the greater their perfection in the firing."

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Volume 14 MARCH, 1935 Number 3

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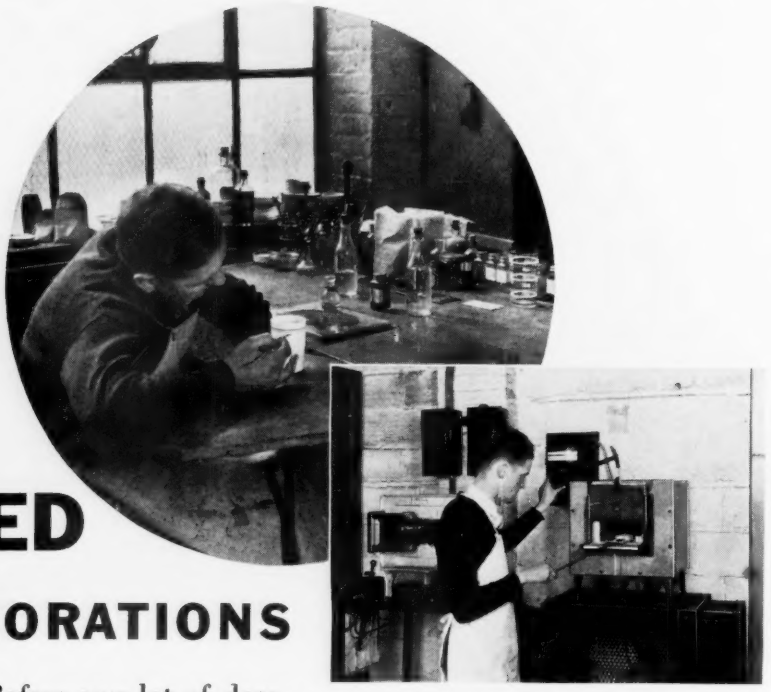

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Volume 14 **March, 1935** **Number 3**

TABLE OF CONTENTS

Papers 101

Effect of Fused Alumina and Boron Oxide on Plastic Fire Clays—D. G. Moore and R. K. Hursh 106
Microscopic Study of Russian Chinaware—George James Middleton 101
Petrology of the Pennsylvanian Shales and Noncalcareous Underclays Associated with Illinois Coals. Part I—Ralph E. Grim 113
Raw Leadless Glazes at Low Temperatures—C. W. Merritt 104
Water Jackets for Glassmelting Tanks—L. T. Sherwood 119

Activities of the Society 121

Annual Meeting in Buffalo, February 17 to 22, 1935 121
California Section News—T. S. Curtis 128
Central Ohio Section Meets—C. R. Austin 128
Constitution and By-Laws Proposed Changes 125
Geological Surveys Committee Supplemental Report—W. M. Weigel, Chairman 124
Local Section News 128
Memorial to Charter Members Who Passed Away This Year—W. D. Richardson 125
Message from Hotel Statler Representative 127
Montana Clay Products Manufacturers to Organize Local Section—W. W. Kriegel 128
Necrology—Charles Shepard Reed 127
New Members 127
Refractories Division Committee on Rules Report—D. W. Ross, Chairman 123
Research Committee Report—J. M. McKinley, Chairman 122
Resolution in Memory of Charles F. Binns 126
Resolution in Memory of William D. Gates 126
Roster Changes During February 128
St. Louis Section Elects Officers for 1935—H. W. Weber 128

Advertisers' Index 11

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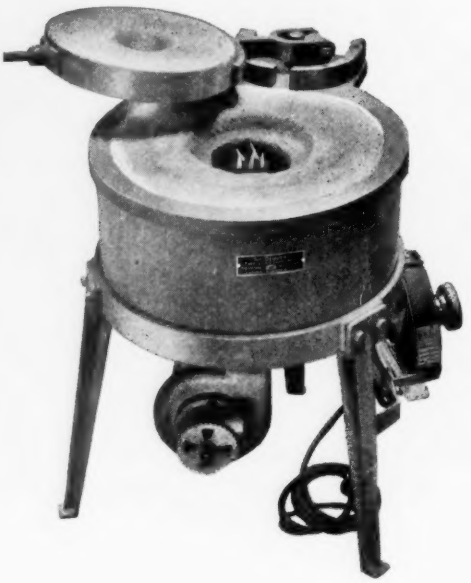

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of Technical, Scientific, and Art Questions

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PAPERS

A MICROSCOPIC STUDY OF RUSSIAN CHINAWARE*

By George James Middleton

Abstract

The history of the Imperial Porcelain Factory is given briefly and the development of body and glaze in comparison with modern china is shown.

I. Introduction

Six pieces of Imperial Russian chinaware, from the collection of Russian treasures gathered by Dr. Armand Hammer of New York City, were given to the ceramics department of the University of Washington. Photographs were taken of the repaired pieces, and thin sections were made from four of them. A brief history of the Russian chinaware will be given before the description of the thin sections.

II. History

The history of Russian Imperial Porcelain has an interest because of its peculiar development and manifold influences. The development of a porcelain body was a slow process. The decoration of the ware was influenced from three main sources: the Musselmanic of the Tartars, the Far East, and, in later years, the close contact with the West. In Russia, very little was known of the history of Russian china, and even a handbook on the subject in English is not known by the author. The Anatra Collection sold in Paris in 1922 was not correctly valued, so the porcelain was not given sufficient importance and became scattered. The Hammer Collection in America is probably the last great collection of Imperial Russian china that will ever be assembled.

In the story of Russian porcelain the Imperial Porcelain Factory played the most important part even in the last years of the old dynasty, for it had no local competition in its artistic productions. Its history falls naturally into three parts of about fifty years each: first, the fabrications of the last half of the 18th Century; second, from 1800 to 1860; and third, from 1860 to the beginning of the World War.

Peter the Great, the first Russian Czar to visit Europe, was a great lover of porcelain and stoneware and he made several attempts to buy the secret of china making from the Germans of Saxony and also from the Chinese. He paid large sums, but in each case some ingredient was withheld by the wily foreigners, so that his efforts met with little success. However, his daughter Elizabeth had better luck. A man called Christoff Conrad Hunger, who claimed to have learned some of the secrets from the master, Böttger, was given great power and in 1744 Elizabeth founded a factory in which he could carry on his experiments. In reality, Hunger was a "four-flusher," and when his experiments with clay and quartz failed he blamed the witches! Finally he was expelled.

Fortunately, Hunger had had as an assistant young Dmitri Vinogradoff, who had studied metallurgy at the University of Freeberg in Breslau. Elizabeth gave this man a position in her cabinet and encouraged him to proceed. To him goes the glory of discovering the formula of Rus-

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (White Wares Division). Received January 29, 1934.

sian porcelain. His discovery was no accident, his results coming only after thirteen years of hard investigative labor under unfavorable conditions. He died of despair and alcoholism in his forty-eighth year.

After his death the factory declined until Catherine the Great came to the throne as Elizabeth's successor and appropriated 75,000 roubles per year for its upkeep, making one of her Cabinet ministers directly responsible for its success. The first great headmaster was Joseph Regensburg of Vienna, and immediately came a flowering of artistic achievement. Of great artistic influence also was the Russian academician, Sacharoff, and the master of models, Rotemb, a Frenchman. During her reign, in 1771, the first pieces of glassware were produced. Paul I made no changes in the factory.

This now brings us to the second part of the development of the Russian Imperial Porcelain Factory. Alexander I brought masters from Berlin and Paris. Under the administration of Nicholas I manufacturing extended to mirrors as well as china and glassware. By this time the greater number of artists were Russians and the privilege of making fine porcelain for the Czars had become hereditary. For the first time Russian china was exhibited in St. Petersburg and in foreign cities, being received with great surprise and admiration and in 1852 taking the gold medal in the London Exposition. The fine gilding of this period has never been excelled and seldom equalled.

The reign of Alexander II was marked with many technical improvements. Russian china had now assumed a national character and its fine taste remained on a high plane, its decline coming only with the freeing of the serfs in 1861. Previously the serfs had worked gratis; but now a certain commercial aspect crept in. However, at the beginning of the 20th Century recovery came about and artistic taste was again revived.

The value of Russian Imperial china to the collector is quite unique, for during the entire history of the porcelain factory its products were made exclusively by the order of and for the use of the royal family. Never had any of it been offered for sale before the Revolution; but a few fortunate people received gifts of this beautiful porcelain from the Czar, and several daring connoisseurs bribed the servants of the palaces to purloin a bit of it. Today much of it that was found in the palaces of the Romanoffs has been scattered through Soviet restaurants and workers' kitchens where, of course, it has been rapidly demolished. For these reasons this exquisite tableware, which formerly graced the banquets and *petite déjeuners* in the most extravagant monarchy of modern times, will always be rare and therefore precious and desirable.

III. Microscopic Procedure

For the microscopic study of the Russian ware, thin sections of the pieces were made and studied by the same methods as are used for geological rock sections. The sections were ground obliquely to the surface of the piece in order to increase the amount of glaze in the section, and were made of pieces broken from parts of the ware where the glaze was thickest. Particular attention was given to the contact between the body and the glaze.

In making the petrographic analyses of the sections, the materials composing them were listed in four classes. The first, called the glassy portion of the glaze, was quite clear and petrographic tests showed it to be amorphous. The second class has been called turbid material, which appeared as cloudy and partially opaque masses.

NOTE: In another study this turbid material was found in large quantities in terra cotta glazes but was almost entirely absent from modern porcelain and earthenware glazes. In some cases, by the use of high magnifications, the material could be seen to be cryptocrystalline; but whether the turbidity was caused in all cases by the presence of extremely fine cryptocrystalline material could not be determined.

The third class of material has been listed as cryptocrystalline, appearing as very fine crystals, usually lath-like or needle-like in appearance, and too small for petrographic determination. The fourth class has been listed as undissolved material, and petrographic examination showed this to be quartz. The undissolved particles varied greatly in size according to the original fineness of the glaze materials and to the extent of the flux attack on the larger particles. Bubbles of gas or air were also present in some of the glazes, and the percentage volume of bubbles in these glazes was also estimated.

IV. Results

The following are the petrographic descriptions of the sections made from the Russian ware,

preceded by a description of a section made from a piece of modern American ware for comparison.

(1) Modern American China Petrographic examination of a section of a vitrified china body covered with a clear glaze showed the glaze to be a very clear glass, nearly free of undissolved or turbid material. Reaction between the glaze and the body was shown by the needles which formed at the contact. The division between the body and the glaze was very regular and the glaze had penetrated the body but slightly. The body was made of finely ground materials, the largest undissolved quartz particle measuring less than 0.002 inch in length. The body was also distinguished by the presence of fine needles, which probably were mullite crystals.

(2) Russian Chinaware, 1825 Russian china manufactured in 1825 had a vitrified white body covered with a clear glaze. Instead of the ordinary clear glassy glaze of modern chinaware this glaze was slightly turbid and contained a rather high percentage of undissolved quartz (8%). The glaze also contained quite a number of bubbles or blowholes that appeared as round, clear spots (2%). At least a part of the turbid appearance of the glaze was caused by the presence of very finely cryptocrystalline material (10%). In some spots crystallization had proceeded a little further and fine needles were distinguishable. The glaze and body reacted quite markedly at the contact where needle-like crystals formed. There was also a rather extensive development of needles in the body, which was quite dense. The glaze did not appear to be very finely ground, the largest undissolved quartz particle present measuring about 0.006 inch in length. The petrographic analysis of the glaze follows:

	(%)
Undissolved quartz	8
Cryptocrystalline material	10
Glass	80
Bubbles	2
	100

The high percentages of bubbles and undissolved quartz indicate a siliceous, viscous glaze. The presence of cryptocrystalline material in the glaze, the reaction of the glaze and body at the contact, and the growth of needles in the body indicate a single-fired, porcelain glaze requiring a high temperature for development.

(3) Russian Chinaware, 1830 A piece of the Russian collection manufactured in 1830 is similar megascopically to the 1825 piece. Microscopically, however, it differed considerably from the latter, resembling quite closely the appearance of the modern glazes. The glaze was composed almost entirely of clear, glassy material (94%), with a little undissolved quartz (3%), and a number of rather large bubbles (3%). A reaction between glaze and body was shown by the presence of needle-like crystals on the contact; but the glaze did not penetrate the body to any appreciable depth. There was also a growth of needles in the body, but less abundant than in the 1825 body. The petrographic analysis of the glaze follows:

	(%)
Undissolved quartz	3
Cryptocrystalline material	0
Glass	94
Bubbles	3
	100

The presence of bubbles in the glaze again indicated that the glaze was viscous, but the needles at the contact and in the body indicated a high firing temperature. The particles of undissolved quartz in the glaze were much smaller in size and amount than in the 1825 glaze, which probably means that a larger quantity of fluxing materials were used, that the glaze materials were better ground, or that the ware was better matured.

(4) Russian Chinaware, 1860 A piece of the Russian ware manufactured in 1860 is megascopically similar to the other pieces in the collection, having a vitrified white body covered by a clear glaze. Under the microscope this section appeared to be quite similar to the section made from the 1830 piece, the glaze being mostly glassy (94%) with some undissolved material (5%) and a few bubbles. Turbid material, apparently cryptocrystalline, along the contact indicated a reaction between the glaze and the body but very few distinguishable needles were present. Although the body had a dense, fine-grained structure the glaze penetrated it quite deeply. The petrographic analysis of the glaze follows:

	(%)
Undissolved quartz	5
Cryptocrystalline material	0
Glass	94
Bubbles	1
	100

Both body and glaze were apparently made of finely ground materials, the largest particle of quartz in the body measuring about 0.003 inch and the undissolved quartz in the glaze being very finely divided. There was little indication of the growth of the needle-like crystals in the body. The penetration of the glaze into the body and the crystalline development at the contact indicate a single-fired porcelain glaze requiring a high temperature for development.

(5) Russian Chinaware for Last Czar A piece of Russian ware manufactured for the last Czar is similar in appearance to the other pieces in the collection. Petrographic examination of the section showed the glaze to be composed almost entirely of glassy material (89%), containing fewer bubbles and probably a higher percentage of fluxes than the earlier glazes. It showed more crystalline development than any of the other Russian pieces. There was a reaction between the glaze and the body, as was shown by the growth of needle-like crystals at the contact, and there were also patches of these needles in the glaze. The glaze penetrated the body to a considerable depth, although the body had a dense structure. Solution of the particles of quartz in the body appeared to have started. Following is the petrographic analysis of the glaze:

	%
Undissolved quartz	5
Cryptocrystalline material	5
Glass	89
Bubbles	1
	100

V. Conclusions

The glazes on the chinaware made in the Imperial Porcelain Factory, particularly the older pieces, were quite different in structure from the glazes on modern chinaware. The older glazes apparently were not as finely ground as the present glazes, and the undissolved quartz and the bubbles indicate that they were of the viscous, siliceous type. The body and glaze were probably developed together in a single firing. The study should be continued by chemical analysis to note the changes in composition during the period represented by this collection.

Acknowledgment Grateful acknowledgment is extended to Hewitt Wilson of the Ceramic Engineering Department for his helpful advice and criticism in the preparation of this paper. Indebtedness is also acknowledged to Alva Lowrey of Marshall Field and Company, Chicago, for the information regarding the history of Russian chinaware.

Department of Ceramic Engineering
University of Washington
Seattle, Washington

A SERIES OF RAW LEADLESS GLAZES AT LOW TEMPERATURES*

By C. W. Merritt

Abstract

Various glaze compositions were compounded using colemanite as a flux. Colors were introduced and some interesting effects obtained by blending.

I. Introduction

There is a need for a reliable raw leadless glaze for use in studio pottery production and also in educational work, especially in the elementary schools. This glaze must also lend itself to the development of a series of pleasing colors. With these points in mind this work was done. Other considerations which have arisen since the start of this work are adaptability to hand grinding and the effect on underglaze colors.

Only glazes maturing at temperatures from cones 04 to 02 are reported at this time although some work has been done at lower and higher temperatures.

The first aim was to produce a reliable clear or semiopaque glaze which could be used as a basis for colors.

II. Materials

In the course of this work many materials were used to find those most suitable both as to fusibility and workability.

It was found that a soda-potash feldspar gave better fusibility and worked into the glaze just as well as a fairly pure potash feldspar. The RO content in the formula of the soda-potash feldspar is about 0.64 Na_2O and 0.36 K_2O. This feld-

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Art Division). Received February 15, 1934.

spar was used in succeeding tests and its RO content designated in the glaze formula as KNaO.

Natural cryolite was used in some of the early experiments as a source of insoluble Na_2O.

A finely ground colemanite† from California, about 98% of which would pass through a 100-mesh screen, was used. The formula was that of the pure mineral, $2CaO{\cdot}3B_2O_3{\cdot}5H_2O$, with a weight of 412. Although a chemical analysis showed that it differed rather widely from the pure mineral, it was thought advisable to use the formula of the pure mineral rather than try to change with each shipment, should it be of different composition.

Two types of zinc oxide were used, one the regular light fluffy variety and the other a heavier or calcined type known as Ceramatone-F zinc oxide. The latter minimizes the danger of cracking or crawling. If only the light variety is available it would be well to calcine it before using.

Regular grades of commercial barium carbonate and flint were used and either Georgia kaolin or English china clay was the source of clay. No mucilage is needed in any glaze of this type because the colemanite is a strong deflocculating agent.

III. Procedure

Several series of glazes were compounded to find a combination of oxides which would produce a reliable glaze at the temperature desired. At first cryolite was used as an auxiliary flux and as high as 0.08 equivalent of cryolite, yielding 0.24 equivalent of Na_2O. A good base glaze, using a small amount of cryolite, was developed and had the following calculated formula:

(A)	KNaO	0.20	Al_2O_3 0.32	SiO_2 3.20
	Na_2O	0.15		
	CaO	0.50		B_2O_3 0.75
	BaO	0.05		
	ZnO	0.10		

A series of color tests were run using this glaze as a base but the results were not pleasing and it was thought that the cryolite had some affect on the coloring power of the coloring oxides. With colemanite alone as the important flux, good results were obtained. Both zinc oxide and barium oxide blended well with the KNaO from the feldspar and the CaO from the colemanite in the RO group, and with the sum of the latter two oxides 0.6 equivalent, the remaining 0.4 equivalent can be divided in any proportion between zinc and barium. From the latter trials the following two glazes were chosen for color series:

(B)	KNaO	0.20	Al_2O_3 0.28	SiO_2 3.00
	CaO	0.40		
	ZnO	0.30		B_2O_3 0.60
	BaO	0.10		
(C)	KNaO	0.20	Al_2O_3 0.30	SiO_2 3.00
	CaO	0.40		
	BaO	0.40		B_2O_3 0.60

All glazes were prepared by ball-mill grinding, the colorless glazes being ground one hour and the colored glazes one and one-half hours. The glazes were washed from the mills with an excess of water which was siphoned off, and the glazes were applied to test pieces without being dried out. The test pieces used were white wall tile bisque and buff tile and small cast vases.

IV. Blending Methods

All blending was done with the glazes after they had been brought to a uniform specific gravity of 1.25.

The glazes seem quite thick, but work well by both the dipping and spraying methods. Application by spraying was the method most used in these trials. The glazes can be applied quite thin with good results.

V. Results

A formula representing the practical limits of the various oxides that were used is as follows:

KNaO	0.20–0.30	Al_2O_3 0.25–0.35	SiO_2 2.50–3.75
CaO	0.40–0.50		
BaO	0.40–0.00		B_2O_3 0.60–0.75
ZnO	0.0 –0.40		

High zinc oxide produced a semiopaque glaze, while the glazes high in barium were transparent. The high zinc glazes did not craze on any of the tests made but the high barium glazes produced slight crazing on the buff tile and cast vases, probably due to the higher coefficient of expansion of the barium. These glazes are all quite viscous and for that reason must be applied rather carefully to prevent crawling or bare spots, particularly pulling away from the edges. No crazing resulted on any of the white wall tile bisque.

The amounts of the coloring oxides used in the base glazes B and C are as follows:

(1) 5% black copper oxide
(2) 2% cobalt carbonate
(3) 10% red oxide of iron
(4) 8% manganese dioxide
(5) 3% green chromium oxide containing 20% antimony oxide
(6) 10% uranium oxide
(7) 10% granular rutile
(8) 10% granular ilmenite

† Obtained from Harshaw Chemical Co., Cleveland, Ohio.

The entire color series using base glaze B had a waxy lustrous appearance and the texture was between a bright and a semimat. This surface appearance was due to the qualities imparted to the base glaze by the zinc oxide. The color results of this B series are as follows:

NOTE: The letter B designates the base glaze while the number or numbers designate the coloring oxide. For instance, if we were using base glaze B and No. 1 color (copper oxide) and No. 2 color (cobalt oxide), then the trial marked B1–2 would be a blend of equal parts of glazes B1 and B2.

B1, medium blue-green
B2 medium violet-blue
B3 dark brown
B4 light red-violet
B5 medium yellow-green
B6 medium orange-yellow
B7 cream
B8 milky gray
B1–2 medium green-blue
B1–3 moss green
B1–4 light gray-green
B1–5 gray-green darker than B1–4
B1–6 medium yellow-green
B1–7 light green
B1–8 olive green
B2–3 dark gray-blue
B2–4 medium violet
B2–5 medium blue-green
B2–6 medium gray-blue
B2–7 powder blue
B2–8 milky gray-blue
B3–4 medium gray-brown
B3–5 medium brown (lighter than B3–4)
B3–6 light yellow-brown
B3–7 milky gray
B3–8 gray-brown
B4–5 drab
B4–6 light tan to violet
B4–7 violet (lighter than B4–6)
B4–8 warm tan
B5–6 medium yellow-green
B5–7 medium gray-green
B5–8 medium violet-brown
B6–7 light straw color
B6–8 medium tan
B7–8 medium gray-tan

This series contains a number of interesting colors which show the high-lights on a modeled piece very clearly.

The colors produced by the blends in the C glaze were about the same as the B series except that the transparent nature of this glaze had a tendency to darken all of the colors and the surface was quite brilliant. The chrome greens were the only colors which were better than the corresponding tests in the B glaze. The transparent colors in this series were not as interesting as those in the B glaze.

VI. Conclusions

(1) The slight solubility of the colemanite did not cause trouble in any of the glazes made.

(2) These glazes can be hand-ground with good results if the colemanite is as finely ground as that in use in these experiments.

Some of the coloring oxides will produce a speckled effect which, in some cases, is quite pleasing.

(3) Glazes of this type can be stored either wet or dry. Some of these glazes have been dried out and used and some have been stored wet as long as five months.

(4) The transparent glazes show good possibilities for use over underglaze colors.

NEW YORK STATE COLLEGE OF CERAMICS
ALFRED UNIVERSITY
ALFRED, NEW YORK

THE EFFECT OF FUSED ALUMINA AND BORON OXIDE ON PLASTIC FIRE CLAYS*

BY D. G. MOORE AND R. K. HURSH

ABSTRACT

A by-product fused alumina grain and also B_2O_3 were added in small quantities to three plastic refractory bonding clays. With clays of low impurities, 2% B_2O_3 addition lowered thermal expansion, increased spalling resistance, decreased shrinkage, and improved refractoriness under load. No beneficial effects were noted in a clay of higher silica and impurity content.

Fifteen per cent fused alumina did not appreciably affect the thermal expansion of any of the three clays, but resistance to thermal shock was improved in a Pennsylvania clay and a northern Missouri plastic clay. All tests were made on bars, 4 by 1 by $^5/_8$ inch, dry-pressed at 2500 pounds per square inch, and fired at cone 14.

I. Introduction

A search of the literature failed to reveal any previous work on the effect of small quantities of fused Al_2O_3 and B_2O_3 on refractory clays. Previously, larger quantities than 15% of fused alumina had been used.

II. Experimental

The clays used were designated as (A) northern Missouri semiflint plastic, (B) Pennsylvania plastic, and (C) Tennessee ball clay, No. 5.

Representative chemical analyses are shown

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in the following table. The analysis of the Pennsylvania clay is listed only as being typical of similar clays from that district.

	A*	B†	C‡
SiO_2	46.29	58.68	46.65
Al_2O_3	35.72	24.95	33.15
Fe_2O_3	1.72	2.39	2.04
TiO_2	2.03	1.70	
CaO	0.45	0.19	0.35
MgO		0.70	0.40
Alk.	0.60	Not determined	0.71
Ignition loss	12.70	8.16	16.45
TOTAL	99.51	96.77	99.75

* Communication.
† *Bur. Stand. Jour. Research*, **3**, 698 (1928).
‡ H. Ries, "High-Grade Clays of Eastern U. S.," *U. S. Geol. Surv. Bull.*, No. 708, p. 271 (1922).

The clays were ground in a dry pan until over 90% passed a 30-mesh screen. Under the microscope the ball clay appeared the finest, the Missouri clay next, and the Pennsylvania clay, the coarsest.

The Al_2O_3 was a finely ground fused alumina grain, a by-product of aluminous abrasives, available at a price of $20 to $30 a ton in carload lots. The screen analysis (Tyler standards) and the most probable limits of the chemical composition of the Al_2O_3 fines are as follows:

Mesh	Screen analysis (%)		Chemical composition (%)
On 48	Trace	Fe_2O_3	1.70*
On 100	0.3	Al_2O_3	Over 90
On 200	20.6	TiO_2	2–3
Through 200	79.0	SiO_2	2–5
		Other impurities under 3%	

* Sample heated in HCl and iron determined as Fe_2O_3 by Zimmerman-Rheinhardt method.

The true specific gravity of the material as received was 3.96; with the iron removed, it dropped to 3.93. The B_2O_3 was an ordinary commercial brand of boric acid.

The following table shows the compositions used in the study.

Batches were mixed dry in a ball mill. Moisture was introduced by spreading the batch uniformly over a damp cloth which was then placed on a wet plaster slab. About twelve hours were required by this method for the mixes to acquire the right moisture content for pressing.

NOTE: No attempt was made to control the water content accurately, but from the constancy of the procedure this could not have shown much variation on mixtures containing the same brand of clay. Due, probably, to the low water content, no scumming was formed on any of the pieces containing boric acid.

All specimens were dry-pressed in a small hand-operated hydraulic press. The bottom plate was inserted, the green mix poured in and leveled off, the top plate inserted, and the pressure applied and held for 30 seconds. The finished test pieces showed good uniformity of structure and there was no evidence of pressure cracks.

TABLE I

Mixture No.	Plastic clay (%)	Fused alumina (%)	B_2O_3 added as H_3BO_3 (%)	Type of plastic clay
A-1	100	0	0	Northern Missouri semi-flint
A-2	95	5	0	
A-3	85	15	0	
A-4	95	5	2	
A-5	95	5	5	
A-6	85	15	2	
A-7	100	0	2	
B-1	100	0	0	Pennsylvania fire clay
B-2	95	5	0	
B-3	85	15	0	
B-4	85	15	2	
B-5	100	0	2	
C-1	100	0	0	Tennessee ball clay
C-2	95	5	0	
C-3	85	15	0	
C-4	85	15	2	
C-5	100	0	2	

The specimens were fired to cone 14 in 24 hours in a gas-fired laboratory furnace. A few pieces of each mix were also fired to cone 14 in 40 hours in an oil-fired laboratory kiln. In the first case an open setting was used while in the latter the specimens were placed in saggers.

Linear shrinkage was measured on all test pieces to $\pm 0.1\%$ by means of a caliper square. In no case was any drying shrinkage noted.

For determining the softening under load of the fired test pieces, a sag test was devised in which each specimen could be placed under the same maximum fiber stress and then carried to a temperature at which a pronounced deformation took place. The manner in which the load was applied is shown in Fig. 1(*b*). The position of the Alundum block (*d*) to give the load necessary to produce the desired fiber stress was determined from the following equation:

$$x = \frac{WL - 2P(L - a)}{2(W - P)}$$

Where x = distance from end of load bar to knife edge (d).
W = wt. of load bar of uniform structure.
L = length of load bar.
P = concentrated load necessary at center of specimen to produce desired fiber stress.
a = overhang distance of load bar at application end.

The effect of the weight of the specimens themselves was found to be negligible and hence this

factor was not taken into account in the calculations.

The load bars (high alumina soap brick), were supported on knife edges composed of 85% silicon carbide and 15% ball clay previously fired to cone 30.

NOTE: The specimens in the first test were supported at the ends by clamping between high-quality fireclay brick and loaded as cantilever beams, thus obtaining maximum fiber stress with minimum load. This set-up was not satisfactory inasmuch as it required four or five brick over the end of the specimens to obtain proper rigidity, which was a bulky and troublesome arrangement. For this reason, all further tests were made using the arrangement shown in Fig. 1(*b*).

In all load tests except the first, a small gas-fired laboratory furnace was used in which a good uniformity of temperature was maintained throughout. Conditions during most of the run were slightly reducing. Four specimens were placed in the furnace for each test and the temperature brought to a maximum in from six to eight hours. A peep-hole in the door allowed visual observation of the progress of the sagging.

At high temperatures there might be an appreciable volatilization of the B_2O_3. To determine quantitatively how much of the B_2O_3 was volatilized from the body, the loss in weight of a number of pieces fired to cone 14 in 40 hours was obtained within ± 0.01%.

The expansion behavior of several of the different mixtures below 700°C was determined by means of the interferometer. The specimens for this test were cut from bars previously fired to cone 14 in the 40-hour firing.

The apparent porosity was obtained by the saturated weight method on all pieces fired in 40 hours. The specimens were saturated by evacuating at 2 inches of mercury for 12 hours while immersed in distilled water. Because of the high percentage of sealed pores in most of the bodies, it was necessary also to determine the true porosities of a few of the pieces by the true specific gravity method.

According to work done by Parmelee and Westman[1] there is a decrease in transverse strength of ceramic bodies after they have been subjected to severe thermal shock. The amount of this decrease can be used as a measure of the spalling resistance.

[1] C. W. Parmelee and A. E. R. Westman, "Effect of Thermal Shock on Transverse Strength of Fireclay Brick," *Jour. Amer. Ceram. Soc.*, **11** [12], 884 (1928).

In the test used, thermal shock was effected by inserting the cold trial pieces into a large electric furnace maintained at 900°C. After ten minutes, they were withdrawn and supported on edge over an air blast. Only six specimens were used for each run and no more than two specimens of any one mixture were handled in the same group of six.

The transverse strength data were obtained on an Olsen testing machine with center loading on a span of $3^1/_8$ inches and with a constant rate of load application of 120 pounds per minute.

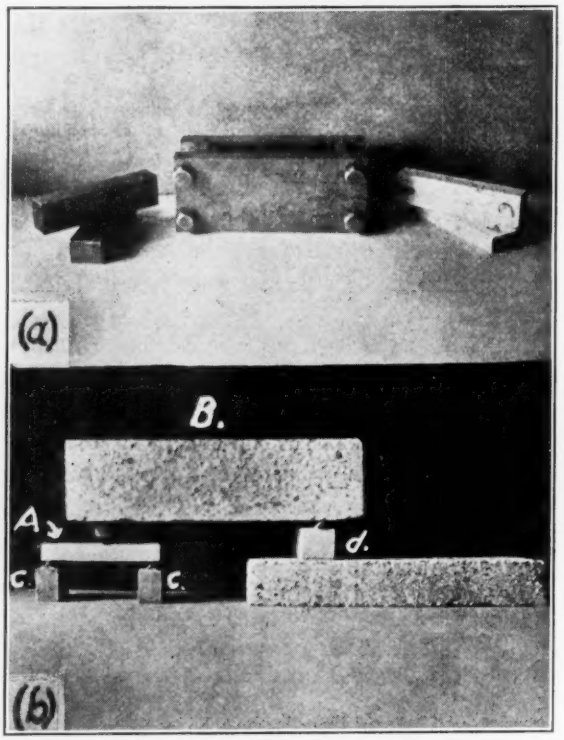

FIG. 1.—(*a*) Mold used for pressing, showing top and bottom plate and two unfired specimens.
(*b*) Arrangement in refractoriness-under-load tests. Specimen *A* rests on SiC knife edges cemented to the Alundum blocks, *c*. The load at the center of *A* is applied by means of the high alumina soap brick, *B*. The load is varied by changing the position of the Alundum block, *d*.

III. Discussion of Results

(1) Shrinkage In all mixtures with B_2O_3 there was an appreciable decrease in firing shrinkage (with 5% B_2O_3), amounting to as much as 1.9%; 2% boron oxide caused approximately the same decrease in shrinkage as did 5% fused alumina, while 5% boron oxide gave about the same reduction as 15% fused alumina. The

principal reason for this, as shown in Table II, is that there is an increase in the true specific volume (decrease in true specific gravity) of the fired mixtures containing B_2O_3 without an accompanying decrease in the total pore volume or true porosity.

The same relative decrease in shrinkage was also noted on a few specimens fired to cone 12 in 36 hours.

(2) Loss of B_2O_3 An examination of the results in Table II shows that the percentage of boron oxide lost is in no case over 10.2% and that it is apparently dependent on the true porosity. The two densest bodies, A-7 and C-5, instead of showing any B_2O_3 volatilized, actually increased in weight when compared to the theoretical loss, indicating that either all of the water had not been driven off from the boric acid or that there were some very complex changes taking place in the body. When these results were obtained, it was felt advisable to determine the water content of the boric acid. This checked almost exactly with the theoretical value.

There was not time enough to determine the effect of repeated heatings on the quantity of B_2O_3 lost. After the first firing, however, it seems logical to believe that B_2O_3 is present in a more stable glass and that the rate of volatilization on further heating should be accordingly decreased.

(3) Sag Test Since the physical structure of the bodies as to particle size is practically uniform, the deformation under the same maximum fiber stress is largely dependent on the viscosity of the glassy phase.

The data in Table II indicate that with Missouri and Tennessee ball clays containing boron oxide there is an actual improvement shown in the refractoriness under load. When the first load test gave this result, it was thought that it must be due to poor temperature distribution during testing. However, a check determination made in an entirely different furnace and with the test bars loaded at the centers instead of at the ends gave almost exactly the same comparative results. That the B_2O_3 had not been volatilized during the test was indicated by the practically constant weight of the specimens containing B_2O_3 before and after testing. Therefore, it seems safe to conclude that the B_2O_3 is present in the body at the temperature of the test as a glass of higher viscosity than the glass formed in the 100% clay bodies.

The greater loading had very little if any effect on the order of refractoriness of the mixtures as shown in Table II. In the first test a maximum fiber stress of 49.7 pounds per square inch was used while in the second test the pieces were stressed only to 27.8 pounds per square inch.

Additions of 15% alumina improved the refractoriness under load of the Pennsylvania plastic and the Tennessee ball clays. In the case of the Missouri clay an actual decrease in the underload refractoriness was noted in bodies both with and without boron oxide. A more pure fused

TABLE II

Mix No.	Linear firing shrinkage (%)	True specific gravity	Apparent porosity (%)	True porosity (%)	B_2O_3 lost from green mixture (%)	Load Tests: Loaded at end max. sag (cm.)	Load Tests: Loaded at center max. sag (cm.)	Spalling Tests: Av. initial modulus of rupture (lb./in.²)	Spalling Tests: Av. final modulus of rupture (lb./in.²)	Spalling Tests: Decrease in strength (%)
A-1	8.65	2.68	3.7	6.4		0.72	0.27	3980	0	100
A-2	8.12					1.00		3760	510	86
A-3	5.85	2.87	13.4	15.9		0.95	0.38	3550	2230	37
A-4	7.66					0.60		3320	3010	9
A-5	6.22		14.5		8.5	0.68		4370	840	81
A-6	5.43		13.8		2.6	0.90*	0.23	2060	1730	16
A-7	8.22	2.62	4.2	12.2	0	0.33	0.19	3260	2500	23
B-1	5.22	2.67	4.2	11.6			0.35	3030	0	100
B-2	5.10							3080	940	70
B-3	3.55		9.6				0.25	3050	1650	49
B-4	2.72		12.0		2.1		0.40	3960	0	100
B-5	4.48	2.63	9.4	15.4	10.4		fractured	3650	0	100
C-1	14.1	2.59	0	5.9			0.35	3320	920	72
C-2	12.9							7100	570	92
C-3	10.9	2.79	2.3	10.6			0.12	5760	1590	72
C-4	10.6		4.0		4.1		0.08	5550	2850	49
C-5	13.0	2.52	0	12.5	0		0.20	3420	3250	5

* Specimen showed crack on tension side.

alumina grain would undoubtedly have given somewhat different results.

(4) Thermal Expansion The effects of B_2O_3 on the thermal expansions of the fired plastic clays below 700°C are especially interesting. In two of the three clays examined the boron oxide was found to lower the total expansion by reducing or entirely eliminating the silica expansion and also by reducing the general expansion of the body. The exception proved to be the Pennsylvania plastic clay.

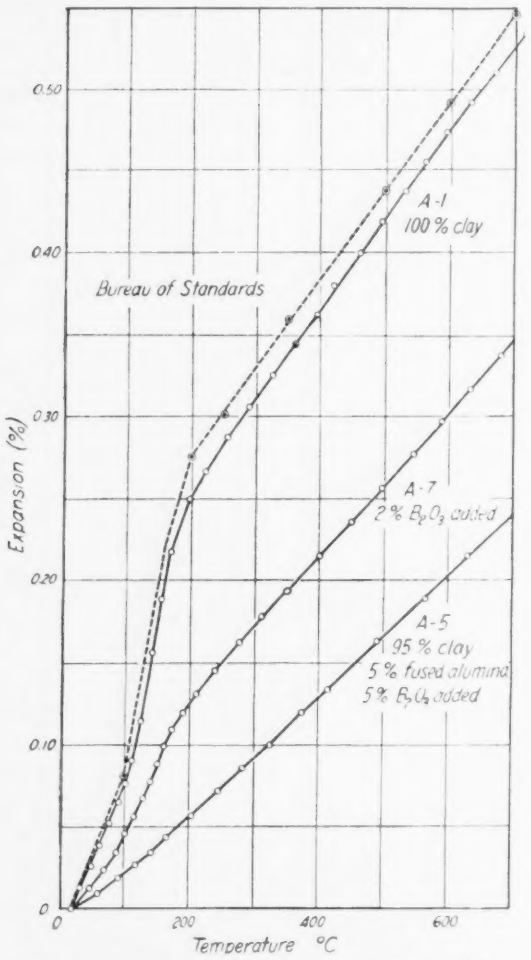

FIG. 2.—Thermal expansion curves for north Missouri semiflint plastic clay bodies fired to cone 14.

In Fig. 2, the thermal expansion curves are plotted for three of the bodies containing the Missouri plastic clay. Curve A-1 represents 100% clay and shows a marked expansion over the range 100 to 200°C. The dotted line is an interferometer curve determined at the Bureau of Standards on a northern Missouri plastic clay fired to 1400°C as reported by Heindl and Pendergast.[2] The close agreement between this curve and A-1 indicates that the two clays are very similar in type.

Curve A-7 in Fig. 2 shows the effect of adding 2% B_2O_3 to the straight clay body, A-1. With A-7 there is a lower expansion below 100°C, an appreciable reduction in the magnitude of the cristobalite or tridymite inversion, and a lowering of the general rate of expansion from 200°C to the maximum temperature of 700°C. Curve A-5 represents the Missouri clay with 5% alumina and with the addition of 5% B_2O_3. There is a still further reduction in the rate of expansion, and, in this case, the silica inversions have been entirely eliminated.

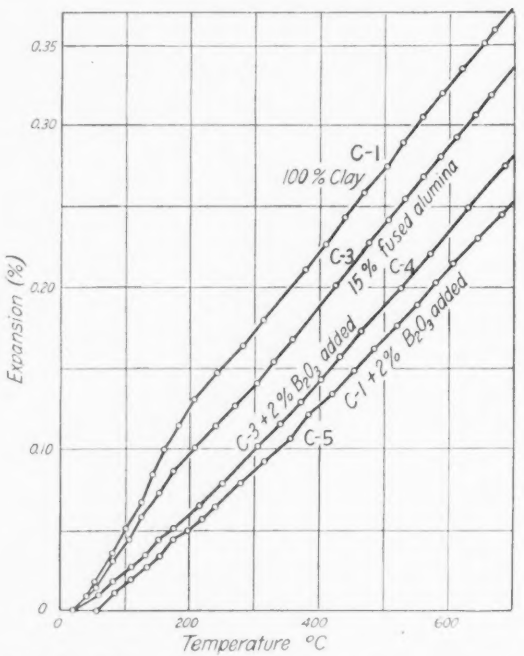

FIG. 3.—Thermal expansion curves for Tennessee ball clay No. 5 bodies fired to cone 14.

The curves in Fig. 3 show definitely the effects of B_2O_3 and Al_2O_3 on the expansion characteristics of the Tennessee ball clay. Curve C-1 represents the 100% clay body, while C-3 shows how the addition of 15% fused alumina decreases the expansion over the range 100 to 200°C. This would suggest the possibility that some of the free silica had reacted with the alumina to form mullite. This theory is substantiated by the improved refractoriness of the C-3 body shown in the load test. Curve C-4 in Fig. 3 shows the

[2] R. A. Heindl and W. L. Pendergast, *Bur. Stand. Jour. Research*, **3**, 702 (1929).

effect of adding 2% B_2O_3 to the C-3 mixture. It will be seen that there are no rapid expansions and that there is a slight decrease in the rate of expansion over the entire range studied. Curve C-5 represents C-1 with 2% B_2O_3 added. Here, also, no rapid expansions are evident and the same general decrease in rate of expansion is noted. C-5 would coincide with C-4 but for the fact that the apparatus was jarred shortly after the determination was started and the initial reading was therefore made at 60°C instead of the usual 20°C.

In Fig. 4, the expansion behaviors of the bodies containing Pennsylvania fire clay are plotted.

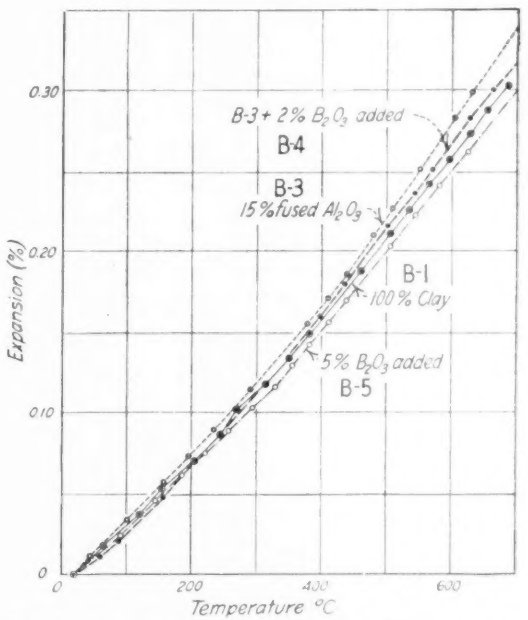

FIG. 4.—Thermal expansion curves for Pennsylvania plastic fireclay bodies fired to cone 14.

In this case, the effects of additions of B_2O_3 and fused alumina are practically negligible. The absence of any inversions is undoubtedly due to the high impurity content, forming a glassy phase with most of the excess silica.

In all of the expansion curves where the silica inversions are manifested, the temperature of the inversion, if considered alone, would indicate the presence of tridymite. However, X-ray diffraction photographs of the Hull powder type gave, besides the mullite pattern, only one clearly defined line and this corresponded exactly with the strongest diffraction line of the cristobalite standard. Also, the large expansion found in the 100% Missouri clay body over the inversion range indicates the predominance of cristobalite over tridymite, although both forms may be present.

That the B_2O_3 is undoubtedly present in a highly siliceous glass is well indicated by the expansion curves of the Missouri and Tennessee ball-clay compositions of Figs. 2 and 3. In all compositions containing boron oxide there was either a decided reduction in the expansion from 100 to 200°C or else a complete absence of any rapid expansion over this range. This can mean only that either a new compound of silica and boron oxide having no inversion temperatures is formed or that the boron oxide has been instrumental in the formation of a glass which has taken most of the free silica into its composition. Of the two possibilities, the latter is by far the more plausible. It is further substantiated by the lowering of the expansion rate both below and above the inversion range, which is a typical condition when additions of B_2O_3 are made to a glass composition. The fading of the cristobalite line into a broad diffuse band, typical of glasses, in the X-ray photographs also tends to prove the presence of the glassy phase. Besides SiO_2 and B_2O_3, the composition of the glass undoubtedly consists of most of the impurities present as well as a substantial percentage of alumina.

(5) Spalling Data in Table II show that the B_2O_3 considerably improves the spalling resistance of the Missouri and the Tennessee ball-clay samples. The resistance, of course, depends on the porosity of the test piece. However, it does not seem likely that the variations in porosity could possibly account for some of the large differences noted. The lower thermal expansion undoubtedly has some effect and it is also quite probable that the B_2O_3 mixtures have a greater elasticity which, according to Booze and Phelps,[3] is of primary importance in determining how a body will act under thermal shock.

(6) Modulus of Rupture The modulus of rupture was determined on three to six untreated specimens and on the same number after going through the thermal-shock treatment. Most of the strength values were fairly uniform on pieces of the same compo-

[3] M. C. Booze and S. M. Phelps, "Study of Factors in Spalling of Fire Clay, etc.," *Jour. Amer. Ceram. Soc.*, **8** [6], 361 (1925).

sition. The greatest deviation from the average occurred in the strengths determined after thermal shock. The maximum deviation here came in the case of the C-3 composition where modulus of rupture values were 215, 1680, and 2860 pounds per square inch. All of the others showed much better uniformity.

The small number of specimens used in determining the strength values can hardly be expected to give true averages. The results do, however, give good indications that there are large differences in resistance to spalling of the various bodies tested. The fact that the 100% Missouri clay specimens all broke during cooling while the same bodies with 2% B_2O_3 added showed only a 23% decrease in strength should not be overlooked in a study of Table II. Also, the effect of alumina additions to the Pennsylvania clay in increasing the spalling resistance is not without some significance.

When boron oxide is introduced as boric acid there are two temperatures at which a softening of the body might be expected during the initial firing. At 185°C the H_3BO_3 decomposes, while at 577°C the B_2O_3 becomes molten. In order to determine how serious these changes might be in affecting the strength of the bodies during early firing, unfired specimens of each of the Missouri clay mixtures were ground to the same thickness (approximately $^5/_8$ inch) and placed in an electric furnace on porcelain knife edges spaced $3^1/_2$ inches apart. The furnace was then brought to 950°C in four hours and held constant for two hours. No deformation took place in any of the specimens.

IV. Summary

The results obtained in the investigation may be briefly summarized as follows:

(1) Boron oxide, when added in 2% quantities to a refractory plastic clay of low impurity content and fired to cone 14, increases the spalling resistance, decreases the thermal expansion, and lowers the shrinkage.

(2) A 2% addition of boron oxide to a refractory clay of higher silica and impurity content has no beneficial effects, when the bodies are fired to cone 14, with respect to refractoriness under load, spalling resistance, or thermal expansion, but it does lower the shrinkage.

(3) Fused alumina of the type used in these experiments, when added in 15% quantities, increases the refractoriness under load of a Tennessee ball clay and of a Pennsylvania plastic clay, but is detrimental in the case of a Missouri clay.

(4) Fused alumina of the type used in these experiments, when added in 15% quantities and the bodies fired to cone 14, improves the spalling resistance of a Pennsylvania clay and a Missouri clay, but has practically no effect on a Tennessee ball clay.

(5) Small additions of fused alumina have practically no effect on the thermal expansion of the clay bodies examined.

In conclusion, the importance of the glass phase in a refractory body is emphasized by the effects of small additions of B_2O_3 to the clay. The resultant changes in the amount and properties of the glass produce marked changes in the characteristics of the body as a whole. It has previously been shown that additions of feldspar, talc, and probably P_2O_5 materially affect the properties of a refractory body, evidently by changes in the composition of the glass. Theoretically, B_2O_3 should have greater possibilities than these other materials in improving resistance to spalling by reducing the thermal expansion and, possibly, by improving the elastic properties. The effects, both qualitatively and quantitatively, however, will depend on the original chemical and mineralogical composition of the clay in question.

Ceramic Engineering Department
University of Illinois
Urbana, Illinois

PETROLOGY OF THE PENNSYLVANIAN SHALES AND NONCALCAREOUS UNDERCLAYS ASSOCIATED WITH ILLINOIS COALS*. PART I

By Ralph E. Grim

Including X-Ray Studies by P. F. Kerr and Chemical Studies by O. W. Rees

Abstract

The mineral composition and texture of a series of Pennsylvanian shales and noncalcareous underclays has been determined by means of improved technique involving petrographic, X-ray, chemical, and dehydration analyses. The data on which the determinations are based are presented, and descriptions for certain clays and shales are given in some detail to show variations in texture and composition.

The shales occurring above and below coals are composed essentially of a potash-bearing clay mineral that closely resembles sericite but that possesses less potash and more water. Quartz, muscovite, and chlorite are present in variable amounts. A few other minerals are comparatively rare.

The noncalcareous underclays are composed essentially of a mixture of kaolinite and the same sericite-like mineral that occurs in the shales. Kaolinite is usually the dominant constituent although the proportions of the two minerals vary in different underclays. Quartz and pyrite are present in small variable amounts. A few other minerals are comparatively rare.

The petrographic characters of these rocks present certain evidence for their origin and later history which are discussed.

This investigation forms the first part of an investigation of the relation between the mineral composition and ceramic properties of the clays and shales of Illinois. The second part of the work involving the study of the ceramic properties of these materials whose mineral composition and texture is now known will be reported later.

I. Introduction

The Illinois State Geological Survey is investigating the petrographic characteristics of the clays and shales of Illinois and the control exerted by these characteristics on the properties that determine the economic utilization of these rocks, especially in processed goods. The mineral composition of clays and shales is as important as their ultimate chemical composition in determining their ceramic properties, but studies of the relation between mineral composition and ceramic properties have been handicapped by lack of mineral data and by the old concept that clays and shales consist almost entirely of kaolinite. Largely as a result of recent work by Ross and Kerr,[1] who have applied improved petrographic technique and X-ray methods to the mineralogical analysis of clays and shales, it is now known

* Published with the permission of the Chief, Illinois State Geological Survey. Received January 8, 1934.

Editor's Note: This paper will be published serially in *The Bulletin*. The following outline and abstract will give the reader a synopsis of the complete paper:

I. Introduction.
II. Method of investigation.
III. Shales occurring above coal horizons.
  (*A*) Constitution of the finer grade sizes (fraction A) of the shales above coals.
    (1) Optical data.
    (2) X-ray data.
    (3) Chemical data.
    (4) Dehydration data.
    (5) Summary of the mineral composition of fraction A.
  (*B*) Constitution of the coarser grade sizes (fraction B) of the shales above coals.
  (*C*) Detailed description of a series of representative shales.
IV. Noncalcareous underclays and shales occurring below coal horizons.
  (*A*) Constitution of the finer grade sizes (fraction A) of the noncalcareous underclays and shales beneath the coals.
    (1) Optical data.
    (2) X-ray data.
    (3) Chemical data.
    (4) Dehydration data.
    (5) Summary of the mineral composition of fraction A.
  (*B*) Constitution of the coarser grade sizes (fraction B) of the noncalcareous underclays and shales beneath the coals.
  (*C*) Detailed description of a series of noncalcareous underclays.
V. Origin of the shales and underclays.
VI. Summary.

[1] C. S. Ross and P. F. Kerr, "The Clay Minerals and Their Identity," *Jour. Sed. Petrology*, **1**, 55–65 (1931).

that the essential constituent of these rocks is not always kaolinite, but may be any one of a series of minerals known as the clay minerals.

The first step in such a study is the determination of the mineral composition and texture of the clays and shales. This report presents the results of such determinations for certain Pennsylvanian clays and shales. The investigation of the relation between the mineral constituents and textures of these rocks and the properties that determine their economic utilization is in progress.

The Pennsylvanian system in Illinois is made up of a series of sandstones, clays, coals, limestones, and shales. Weller[2] and Wanless[3] have shown that these strata exhibit a cyclical repetition from the base upward as follows: sandstone and sandy shale, underclay, coal, marine limestone, and shale: the cyclothems[4] are usually separated from each other by unconformities that represent intervals of erosion.

About 100 samples were collected from the underclay and shale horizons of many different cyclothems and from the same cyclothems in widely separated areas, in order to obtain a representative series and to investigate possible correlations between petrographic properties of the clays and shales and their stratigraphic and geographic distribution.

NOTE: J. M. Weller, paleontologist of the Illinois State Geological Survey, and H. R. Wanless of the University of Illinois suggested the locations from which samples were collected. The X-ray work was done by P. F. Kerr of Columbia University. The chemical analyses and dehydration determinations were made in the Illinois State Geological Survey laboratory under the supervision of O. W. Rees, associate chemist.

II. Method of Investigation

The very small size of the constituents of clays and shales has always made their identification difficult. In order to overcome this difficulty, the following procedure was used in this investigation. The material was disaggregated in distilled water by using an end-over-end shaker. This disaggregated material was then placed in a large battery jar with additional distilled water and allowed to stand until the coarser components had settled to the bottom of the jar leaving the finer components in suspension. From time to time samples of the suspended material were removed, dried, and examined microscopically. By checking in this way the material could be allowed to stand until the suspension appeared to be free of nonclay mineral constituents. Usually a settling period of several hours was sufficient, but occasionally it was necessary to pass the suspension through a filter paper to eliminate nonclay mineral constituents.† The suspended material was then siphoned into another jar and the water was removed by means of Pasteur-Chamberland porcelain filter cones. Drying the material completed the preparation.

Some of the samples were not disaggregated sufficiently by simple shaking in distilled water, but after preliminary wetting and drying most of these were broken down and yielded suspensions. A few samples resisted all efforts at disaggregation and from them fractions of material as fine as possible were obtained.

That portion of the clay or shale existing in very small particles, and larger particles which had been broken down in the process of disaggregation to a size permitting them to remain in suspension, is designated as fraction A for convenience. This fraction is essentially the clay mineral component, but as it contains additional minerals which could not be removed, it can not be designated as the clay mineral constituent. Petrographic, X-ray, and chemical methods were used in studying fraction A.

The fraction not remaining in suspension in the battery jar was washed free of all suspendable material by using dispersing agents. This fraction, called fraction B, includes those particles too large to remain in suspension. This fraction was studied with a petrographic microscope and the mineral constituents were determined.

Finally thin sections of the natural rock were prepared and studied in order to obtain data on its texture and on the actual size and relative abundance of its constituents.

This investigation has shown that the constitution of the noncalcareous clayey sediments occurring below the coals usually differs from that of the shaly sediments occurring above the coals. For that reason they are described separately.

[2] J. Marvin Weller, "Cyclical Sedimentation of the Pennsylvanian Period and Its Significance," *Jour. Geol.*, **38**, 97–135 (1930).

[3] Harold R. Wanless, "Pennsylvanian Section in Western Illinois," *Bull. Geol. Soc. Amer.*, **42**, 801–12 (1931).

[4] H. R. Wanless and J. M. Weller, "Correlation and Extent of Pennsylvanian Cyclothems," *Bull. Geol. Soc. Amer.*, **43**, 1003–16 (1932).

† No technique was found to remove all the fine quartz and organic material completely from the suspension (see (2) X-ray Data, page 115).

III. Shales Occurring above Coal Horizons

Fifty-nine samples from shale horizons above the coals in the cyclothems were studied (Appendix I).* These shales are usually well bedded, often distinctly laminated, very gritty to non-gritty, and may be light to dark gray, yellow, or red. Some of the gray varieties weather to a yellowish hue. Probably the yellow and red colors of many of the shales are secondary.

(A) Constitution of the Finer Grade Sizes (Fraction A) of the Shales above Coals

Under high magnification (1000 diameters) fraction A of every sample proved to be crystalline, consisting essentially of colorless to light yellow-green particles reaching a maximum diameter of 0.002 millimeter. The shape of the individual particles, where determinable, is flake-like. Many of the fractions appear to be homogeneous, *i.e.*, composed entirely of these flake-like particles, but some include variable small quantities of green flakes that have a slightly higher index of refraction than the light yellow-green particles. The green flakes may be fragments of chloritic material although their small size and the greenish color of the dominant constituent makes an absolute identification impossible. Certain fractions also included a few particles that may be quartz, as indicated by a lower apparent index of refraction, but the presence of quartz could not be proved optically. Most fractions contained small quantities of red-brown translucent particles which are probably organic.

The microscopic examination of the finest fractions of the samples (Nos. 262 and 272) from which a suspended fraction could not be obtained shows them to have a composition essentially the same as fraction A of the other shales. The maximum size of the particles is larger, however, reaching 0.01 millimeter, and a few grains of quartz are present.

(1) Optical Data The following optical data show the range exhibited by the colorless to light yellow-green flake-like mineral. In different samples γ ranges from 1.570 to 1.580 (Appendix I)* with one sample as low as 1.563 and another as high as 1.585. The birefringence varies from 0.022 to 0.030, increasing as the index of refraction increases. The index of refraction and the birefringence are higher for the light yellow-green flakes than for the colorless flakes. These light yellow-green flakes are slightly pleochroic with the darker color parallel to Z. The sign is $(-)$, and $2V$ is small with an average value of 15°. These data do not closely coincide with published clay-mineral data except those of the potash-bearing clay minerals. According to Ross and Kerr[5] these minerals are micaceous, resembling sericite. They have an index of refraction of from 1.53 to 1.565, a birefringence of 0.02 to 0.03, a very small optical angle, and a positive or negative sign. The slightly higher index of refraction of the clay mineral in these shales may be well explained by a slight ferric iron content. The chemical analyses show such iron to be present. The optical data, therefore, suggest that the essential constituent of fraction A is a sericite-like mineral belonging to the potash-bearing clay mineral group.

(2) X-Ray Data X-ray diffraction patterns of fraction A (Appendix I) were obtained by P. F. Kerr of Columbia University. The photographs were secured in an X-ray diffraction outfit making use of cassettes with 114.5-millimeter radii. All of the photographs were taken with molybdenum-K–α radiation utilizing zirconium-oxide filters.

The diffraction patterns of all but three (Nos. 221, 244, and 283) of these samples were identical. Kerr[6] reports on them as follows:

> Comparison of the X-ray diffraction patterns with each other and with patterns of standard minerals has led to an experiment which appears significant from the determinative standpoint. So many lines in the X-ray pattern so closely correspond with the X-ray diffraction lines given by sericite that it was felt some relationship must exist between the fine clay mineral and sericite. A few lines, however, could not be explained in this way. Comparison with X-ray patterns of quartz suggested that the additional lines might be due to a small amount of very fine-grained quartz or chalcedony contained as an impurity. Having this in mind, several artificial mixtures of sericite and quartz were prepared in order to see whether the X-ray diffraction patterns of Illinois shales could be successfully imitated. Study of a number of negatives indicates that the imitation was successful aside from the factor of isomorphism. The X-ray diffraction pattern of the micaceous constituent of the Illinois shales, although duplicat-

* Appendix I will be published in a succeeding issue of *The Bulletin*.

[5] C. S. Ross and P. F. Kerr, "The Clay Minerals," *idem.*, p. 61.

[6] P. F. Kerr, "A Report on X-ray Studies of 100 Selected Samples of Illinois Clay." Report in files of Illinois State Geological Survey, 1933.

ing the sericite pattern both in number of lines and intensity, fails to duplicate the sericite pattern exactly in spacing. It would appear, therefore, that the conclusion should not be drawn that the fine colloidal constituent of the Illinois shale is sericite. It seems more likely that the constituent is another member of the mica family isomorphous with sericite.

The name "hydromica" has been used by a number of writers for material of this sort. It is felt by others, however, that the use of this term should be avoided.

The patterns correspond closely to certain patterns of the so-called potash-bentonites of the Ordovician system of the eastern United States. The optical determinations also suggest similarity. The potash bentonites, however, are largely fine mixtures and have not as yet been adequately purified and studied. It appears, therefore, that the precise determination of the micaceous mineral is still a problem. Solution of the problem will be delayed since samples of the clay mineral free from fine quartz or chalcedony are exceedingly difficult to find. Mechanical purification in this case has not yet been successful.

An additional line not present in the mica pattern and occurring at an angle of extremely low reflection, near the zero beam of the negative, indicates the possibility of a small amount of kaolin being present.

Three shales (Nos. 221, 244, and 283) yielded somewhat different patterns. According to Kerr, samples 221 and 244 apparently belong to the same group as the shales, but probably contain more kaolin. Two prominent lines of the kaolin group appear to be stronger in these patterns. The lines of the diffraction pattern of sample 283 appear to lie between those of the shales and the noncalcareous underclays.†

The X-ray data indicate, therefore, that the finest fraction of the shales is a mixture essentially composed of a sericite-like mineral, not identical with sericite but probably forming an isomorphous series with it and quartz. The possibility of the presence of small amounts of kaolin is also indicated.

TABLE I

CHEMICAL ANALYSES OF FRACTION A OF SHALES OVERLYING COAL

(Analyses made under the supervision of O. W. Rees, Illinois State Geological Survey. Locations of the samples are given in Appendix I which will be published in a succeeding part)*

	213	204	288	242	36	240	241	215	217	254
SiO_2	47.59	54.61	55.54	51.02	58.27	57.21	51.19	47.18	53.06	51.85
Al_2O_3	30.04	26.75	25.61	25.30	21.27	18.97	22.31	24.95	26.86	25.60
Fe_2O_3	4.53	1.45	0.53	2.04	1.63	4.66	8.00	8.30	2.42	2.16
FeO	1.66	2.08	1.76	5.06	1.73	2.89	1.66	2.15	3.00	3.49
MgO	2.08	2.16	1.09	2.25	1.23	2.17	2.53	2.26	2.51	2.65
CaO	0.84	0.48	0.51	0.87	0.94	0.92	1.25	0.87	0.76	0.81
Na_2O	0.56	0.83	0.70	0.46	0.93	0.93	0.59	0.51	0.71	0.64
K_2O	3.19	4.84	3.64	2.79	3.93	3.27	4.10	4.03	3.30	4.35
TiO_2	0.62	0.90	3.04	1.39	3.37	2.16	1.44	1.55	0.81	1.49
Ign. loss	8.81	6.69	7.33	8.99	5.91	6.77	6.98	8.28	6.47	6.73
P_2O_5			0.47		0.80					
Total	99.92	100.79	100.22	100.17	100.01	99.95	100.05	100.08	99.90	99.77
H_2O+	8.34	6.06		7.32		5.98	6.46	7.94	6.45	7.17
H_2O-	1.13	0.85	0.63	1.23	0.25	0.27	0.61	0.46	0.96	0.43
SiO_2/Al_2O_3	2.69	3.47	3.69	3.43	4.65	5.13	3.90	3.21	3.36	3.44

	272	202	239	285	243	270	280	262	229
SiO_2	57.08	49.50	48.44	50.90	46.68	51.57	52.37	51.50	47.89
Al_2O_3	21.93	27.60	26.68	25.80	27.74	23.79	23.62	24.51	25.99
Fe_2O_3	2.10	2.10	6.76	2.39	7.37	2.88	2.84	2.73	8.61
FeO	3.78	3.37	1.64	3.76	1.18	5.07	4.93	3.89	0.90
MgO	2.61	2.66	2.65	2.63	2.35	2.80	2.82	1.70	2.48
CaO	0.66	1.48	0.80	0.63	0.86	0.66	0.76	0.96	0.94
Na_2O	0.76	0.51	0.35	0.84	0.20	0.74	0.80	0.93	0.41
K_2O	2.72	4.57	3.41	4.64	3.75	3.83	3.69	3.77	3.81
TiO_2	2.15	1.17	1.40	1.61	1.35	1.54	1.33	1.49	1.60
Ign. loss	6.21	7.74	7.62	7.29	8.45	6.96	6.81	8.38	7.76
P_2O_5									
Total	100.00	100.70	99.75	100.49	99.93	99.84	99.97	99.86	100.39
H_2O+	5.71	7.66	7.57	7.17	8.52	6.94	6.70	7.82	7.75
H_2O-	1.19	1.32	1.42	0.69	1.89	0.66	0.57	0.99	1.98
SiO_2/Al_2O_3	4.42	3.05	3.09	3.35	2.86	3.68	3.77	3.57	3.13

(3) Chemical Data Chemical analyses of fraction A of the shales above the coals are given in Table I. Suspended fractions of samples 262 and 272 could not be obtained. The analyses of these samples represent the finest fractions obtainable. They show no evident difference from those of other samples.

† Reference is made to data to be published later. This will appear in section IV, paragraph (2) X-Ray Data (see outline on page 113).

The loss on ignition is determined on material dried at 110°C. The water loss below and above 110°C was separately determined. Where there is an appreciable difference between the H_2O+ and the loss on ignition, the difference is probably to be explained by the presence of organic material.

The analyses show similarities, particularly in the K_2O, FeO, MgO, Na_2O, and CaO contents. The water content, although variable, is always small. The silica-to-alumina ratio, however, ranges from about 2.5 to 5. This variation does not necessarily mean a variation in the constituent mineral since the X-ray data show the presence of variable amounts of free quartz.

The ferric iron content also varies. Whether all the Fe_2O_3 exists as a molecular constituent in the clay mineral or uncombined as an impurity can not be determined. A comparison of optical data (Appendix I)* with chemical data (Table I) shows that the birefringence and index of refraction of the clay mineral increase as the Fe_2O_3 increases. Moreover, the samples containing particles that are yellow rather than colorless under the microscope possess the higher ferric iron content. In some of the samples (215, 241, 243), minute opaque particles that are probably limonitic can be seen under high magnification, indicating that in these samples not all the ferric iron is combined in the clay mineral. Therefore, it may be concluded that some, but not necessarily all, of the Fe_2O_3 shown by the analyses exists as a molecular constituent in the clay mineral.

The analyses show that fraction A of the shales is essentially a hydrous aluminum silicate. The X-ray evidence suggested that this constituent approaches sericite in composition. The usual formula given for sericite is $2Al_2O_3 \cdot K_2O \cdot 6SiO_2 \cdot 2H_2O$. Calculations show that the mineral in fraction A is similar in composition to sericite, but that it has a lower K_2O content and a higher H_2O content. The variations in composition shown by the analyses suggest that the composition of this mineral is variable.

According to Ross and Kerr,[7] the potassium-bearing clay minerals resembling sericite differ from other clay minerals in being low in water, high in bases of which K_2O forms an essential part, and high in silica. This closely agrees with the composition of the mineral in the Illinois shales and agrees with the optical and X-ray data in placing the mineral in this clay mineral group.

Microscopic examination (p. 115) indicated in fraction A of some samples the presence of a small quantity of green flakes which was tentatively determined as chloritic material. This would explain the small but noteworthy quantities of FeO and MgO except for the fact that not all the samples contain distinct chloritic material whereas all their analyses do show FeO and MgO in appreciable quantities. It is probable that these oxides are also contained in the clay mineral, a conclusion suggested by the greenish color of the clay mineral in many of the shales.

TABLE II

DEHYDRATION OF FRACTION A OF SHALES OVERLYING COALS*

	Moisture loss (%)				
Temp., (°C)	242	241	215	270	254
110	0.64	0.88	0.36	0.22	0.42
160	0.94	1.19	0.81	0.50	0.57
250	1.32	1.59	2.14	0.87	0.56
300	2.07	2.55	3.44	1.51	0.86
350	2.78	2.99	4.06	2.14	1.21
375	3.06	3.19	4.38	2.54	1.26
400	3.55	4.19	4.62	2.66	1.66
450	5.66	5.46	6.51	3.54	3.15
485	6.56	5.94	7.91	5.52	4.09
530	7.35		8.66	6.23	
540		6.70			5.43
600				6.93	
615	8.15	7.35	9.22		6.52
650	8.27	7.33	9.23	6.95	6.50
700	8.50		9.58	7.30	
750	8.66	7.63	9.71	7.44	6.92
1000	9.18	8.36	10.20	7.91	7.38

* Determinations made under the supervision of O. W. Rees, Illinois State Geological Survey. Locations of the samples are given in Appendix I.

The form in which the TiO_2 exists in fraction A is not definitely determinable. Under high magnification (1000 diameters) a few grains that appear to be needles of rutile can be found, but the presence of titanium minerals can not be proved. Small quantities of such minerals would probably not be detectable in this fraction and their apparent absence does not necessarily mean that the TiO_2 occurs in the clay mineral.

(4) Dehydration Data Dehydration data for fraction A of five shales are given in Figs. 1 and 2 and Table II. The dehydration curves show general uniformity in a low loss of water at 110°, a slow gradual loss from 110 to 250° (except sample No. 215), a

* Appendix I will be published in a succeeding issue of *The Bulletin*.

[7] C. S. Ross and P. F. Kerr, "The Clay Minerals," *idem.*, p. 59.

fairly rapid gradual loss from 250 to 600°, a small gradual loss above 600°, and a low total loss of water.

The absence of dehydration data on many clay minerals prevents the use of the data above in the classification of the clay mineral of fraction A. They indicate, however, that it is not a member of the kaolin group or the beidellite-montmorillonite-nontronite groups of clay minerals, since the dehydration curves of these clay minerals[8] are known to be different from those in Fig. 1.

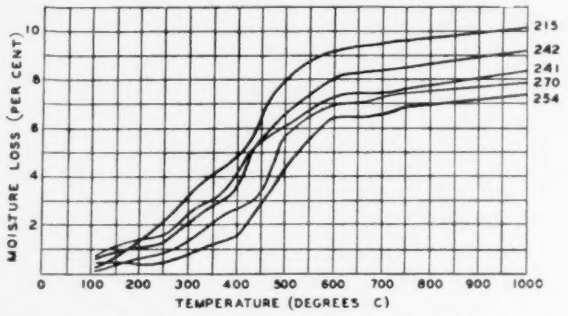

FIG. 1.—Dehydration curves of fraction A of shales overlying coals. Locations of the samples are given in Appendix I.

Rees,[9] who supervised the determination of the dehydration data for fraction A, comments as follows:

> The method used in obtaining the dehydration data for the clay samples was that of Ross and Kerr.[10] The total loss obtained by the procedure (heating at various temperatures, cooling, and weighing) is consistently higher than that obtained by the determination of loss on ignition (one heating at 1000°C), as shown by a comparison of Tables I and II. The reason for this is not clear at the present time.

(5) Summary of the Mineral Composition of Fraction A

The X-ray, optical, and chemical data indicate that the essential constituent of this fraction is a mineral similar to but not identical with sericite. According to Ross and Kerr,[10] a clay mineral of this type belongs in a potash-bearing clay mineral group.

According to Dana,[11] sericite is a fine, scaly, or fibrous muscovite characterized by a silky luster. Winchell[12] states that sericite is a fine scaly or fibrous muscovite, and that the name is usually confined to secondary white mica. Recent data[13] suggest that certain sericites contain less potash and more water than muscovite. Damourite, according to Winchell,[12] which includes so-called hydromica, is an altered muscovite containing more water or more easily removed water than unaltered muscovite. Hydromica is also included under damourite by

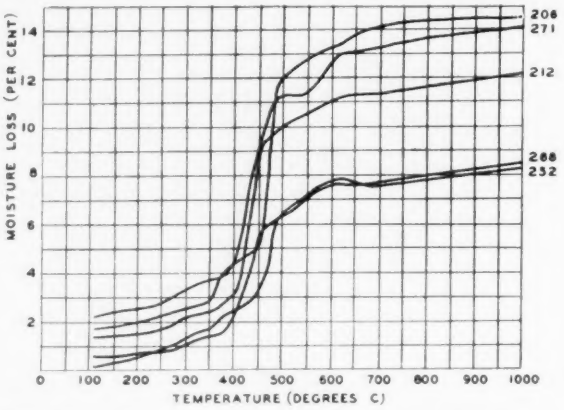

FIG. 2.—Dehydration curves of fraction A of noncalcareous underclays and shales underlying coals.

Dana,[11] who states that its water content may not be higher than that of muscovite, but that its water may be given off more readily.

Hickling,[14] Galpin,[15] Bayley,[16] and Somers[17] have described the occurrence of hydromicas or hydrated micas in various clays. It has been pointed out that this mineral has less potash and more water than muscovite, and also differs optically from muscovite in having a lower index of refraction and a lower birefringence.

The existence of a clay mineral or an isomorphous series of clay minerals possessing similar but not identical chemical, optical, and physical properties with sericite can be considered as established. The clay mineral of the Pennsylvanian shales of Illinois and probably most of

[8] (*a*) P. F. Kerr and C. S. Ross, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165-E, 1931.
(*b*) C. S. Ross and E. V. Shannon, "The Minerals of Bentonite and Related Clays and Their Physical Properties," *Jour. Amer. Ceram. Soc.*, **9** [2], 77–96 (1926).

[9] O. W. Rees, Personal communication.

[10] See footnote 8(*a*).

[11] E. S. Dana, Textbook of Mineralogy. 3rd ed., published by W. E. Ford, New York, 1922.

[12] A. N. Winchell, Elements of Optical Mineralogy, Part II, New York, 1927.

[13] E. V. Shannon, "The Minerals of Idaho," *U. S. Nat. Museum Bull.*, No. 131, p. 367, 1926.

[14] G. Hickling, "China Clay, Its Origin and Nature," *Trans. Inst. Mining Eng.*, **36**, 10–33 (1908).

[15] S. L. Galpin, "Studies of Flint Clays and Their Associates," *Trans. Amer. Ceram. Soc.*, **14**, 301–46 (1912).

[16] W. S. Bayley, "Kaolin in North Carolina with a Brief Note on Hydromica," *Econ. Geol.*, **15**, 236–46 (1920).

[17] R. E. Somers, "Microscopic Study of Clays," chapter in *U. S. Geol. Surv. Bull.*, No. 708, 1922.

the so-called hydromicas are members of this series of minerals. The actual delimitation of the chemical and optical characteristics of the different members of this series is handicapped by the difficulty of obtaining absolutely pure material. Until such material is obtained, it appears wise not to apply a specific name or propose limits of composition for them. In this report, the term "sericite-like mineral" will be used.

The X-ray data indicate that fraction A also contains variable quantities of quartz. Optical data indicate the presence of a trace of chloritic material and the chemical analyses also show that this may be true although all the MgO and FeO may be contained in the sericite-like mineral. X-ray data do not indicate any chloritic material, but the quantity present is probably too small to show in the diffraction pattern. Thin-section study shows definitely that the shales do contain chlorite-like material which often exhibits transition boundaries to the sericite-like mineral. This questionable material may, therefore, be true chloritic substance, transition material from the chloritic substance to the sericite-like mineral, or the sericite-like mineral itself. All three types are probably present occasionally.

The uniformity in the mineralogical composition of the Pennsylvanian shales of Illinois is noteworthy. Shales from a wide stratigraphic and geographic range have been studied, and in every case the identity of the mineral constituents composing fraction A has been the same.

Instalment II will appear in *The Bulletin* for April, 1935.

WATER JACKETS FOR GLASSMELTING TANKS*

By L. T. Sherwood

Abstract

Although the use of water jackets for glassmelting tanks has been commonly spoken of as "water cooling" with a view to preservation of the clay blocks, a materially different concept is herein explained. According to this concept, the water jackets are simply a reliable reinforcement instead of a preservative comparable to air cooling. Economic phases are also briefly discussed.

I. Introduction

The cooling of tank blocks by air from blowers is of course for the purpose of preservation. As an alternative, some factories have placed water pipes, or preferably boxes, against the blocks. The latter practice seems commonly spoken of as "water cooling" of the blocks with a view to preservation, but at least one firm which has employed it for many years has acquired a somewhat different concept (as herein explained by request).

II. Water Jackets Reinforce Blocks Rather Than Preserve Them

In the absence of water jackets, when blocks get very thin it may not be safe to continue operation. On the other hand, when blocks are reinforced by water jackets, correctly designed and used, there need be no fear whatever of dire consequences from block failure. If blocks are penetrated, the glass freezes against the water jacket and can go no further. Although the advisability of continuing operation after numerous blocks have thus failed may be open to question for reasons other than fear of a break, no pressing necessity for shutting down need be experienced. Tanks have been operated with reasonable satisfaction for months after the first penetration. In the good old days, when production was often urgently needed, it was a great advantage not to be compelled to suspend immediately because of thin blocks or merely because a few inferior ones were at the point of failure.

III. Cooling Effect Questionable but Block Life Is Indirectly Lengthened

As to preservation, at the works on whose experience these comments are based, no material lengthening of life can be attributed to

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received December 5, 1934.

cooling of the blocks themselves; nor is there any convincing reason to expect any especial cooling thereof. Surfaces of both blocks and water boxes are too imperfect to hope for uniformly good contact between the two. They actually touch only in spots here and there. Fillers which would insure a rapid transfer of heat have not here proved practical. In fact, cooling of the blocks is facilitated only in the respects that the relatively cool jackets are good absorbers of radiation and that they tend to chill the air in the very narrow and irregular intervening space. It is not known whether or not such effect is greater or less than would be the cooling incident to ordinary radiation and convection in the absence of all artifices.

Although blocks may not be preserved by being themselves kept cooler, it is evident that when they get thin heat travels through them more rapidly and the rate of erosion will presumably slacken because of lowered temperature of glass at the interface. Hence, in the sense that water jackets facilitate operation after the upper blocks have been reduced to mere shells, they may be credited with increased life.

IV. Water Jackets Facilitate Thinner Blocks

Water jackets also have a bearing upon the thickness chosen for new blocks. Although it was not long ago that some firms were using blocks as thick as 24 inches on the reasoning—perhaps natural, but superficial—that the greater the thickness the longer the life, it seems now to be recognized that deterioration is rapid until thickness is reduced enough to promote a material cooling of the glass at the interface. With clay blocks, erosion is rapid until thickness at the "metal line" gets down to only a few inches. Accordingly blocks have been made thin at the top in the first place, tapering to a greater thickness at the bottom to provide a footing and to reduce unnecessary loss of heat. Cost of blocks has thus been reduced, but in at least some cases a still greater advantage lies in the fact that there is less block material to get into the glass and cause faulty production.

V. Concerning Cost

The economics of water jackets *versus* air cooling seem to hinge on individual circumstances. Since air cooling is so widely practiced, it might perhaps be said that its cost can not be excessive. If water rates were high or quality unsuitable the employment of jackets might cost too much, although it should be remembered that reuse after cooling in a spray pond or the like may be economical. Where water is cheap and of good quality the cost is not excessive.

VI. Fuel Consumption Not Unreasonably Increased

The effect upon fuel requirements for melting would be hard to determine precisely. It may not be amiss to say that, since effective air cooling undoubtedly removes more heat than would be lost by ordinary radiation and convection, it tends to raise fuel consumption. On the other hand, there is no proof that water cooling is similarly responsible until the blocks get very thin or are penetrated. As to greater fuel consumption when numerous blocks have been penetrated, figures which would be at all comparable are available for only one "fire." In this tank, which measured about 12 by 55 feet inside, there were, when shut down, roughly 30 square feet where glass was actually against the water jackets. The amount of coal fired to a gas producer during the last full month of operation was 12% greater than during the first month when the blocks were new (May in both cases), but a portion of this increase could fairly be attributed to other causes. It is not known what a representative percentage would be, but at any rate the increase in fuel consumption has never been a deciding factor when shutting a tank down in this works.

Pennsylvania Wire Glass Company
Dunbar, Pennsylvania

ACTIVITIES OF THE SOCIETY

THIRTY-SEVENTH ANNUAL MEETING, BUFFALO, FEBRUARY 17 TO 22, 1935

The program as detailed in the February issue of *The Bulletin* was carried out on schedule. The verbally expressed opinion of many at the conclusion of the Meeting and the written comments of several since the Meeting were unanimous in praise of the high quality of the programs and the manner in which the meetings were conducted. An adequate statement of obligations due to the Division officers and Committeemen for their work many months prior to the Meeting and during the Meeting can not be made here.

To the Buffalo Committee and each of its personnel who planned thoughtfully for several months how to make this Annual Meeting most pleasant we owe much. That they succeeded in a masterful way is the opinion of every one who attended the Meeting. They not only provided bountifully for the social welfare but planned skillfully the many services which made possible the smooth management of the several concurrent meetings. Their management of plant trips to Niagara Falls, Rochester, Corning, Erie, and points in and near Buffalo was carefully planned and expertly executed. The ladies were unanimous and very emphatic in their praise of the plans made and carried out for their entertainment. The Local Committee did itself proud.

The personnel of the Hotel Statler from Elmore C. Green, manager, to the least significant service boy and girl rendered thoughtful and pleasant service. They earned the outspoken admiration without a single exception of those who attended this Meeting. John Daniels, Jr., who was in direct charge of the Meeting accommodations for the hotel contributed very largely to the successful conducting of the meetings by his ever-gracious and ready attention to the many, many demands.

To the students from the New York State School of Ceramics, Alfred, N. Y., who rendered lantern and other services at the several meetings and who were the hosts of the students from other universities, there is a debt of obligation which can not be discharged merely by this statement. Under the leadership of Andrew Fedor the boys and girls from Alfred University were everywhere and on all occasions rendered a happy service. There were about 150 students attending the Meeting from the several universities and each was made to feel at home by the Alfred students.

GRANT S. DIAMOND

It is estimated that considerably more than 1000 men and 150 ladies came to Buffalo to attend these meetings. Over 800 of them registered at the desk. The meeting room accommodations and the management of the meetings were such that this large crowd was impressive only when it happened to meet at one place, such as at the general lectures and social affairs.

We would not single out any one of the Local Committee or of the local corporations who made our stay in Buffalo so pleasant except the Chairman of the local Service Committee who, most of the time, was hidden away in his little office and rendered multitudinous services in so quiet and efficient a manner as not to make himself known even to the officers and committees who were conducting the meetings. We refer to Grant S. Diamond. He it was who made plans far beyond those requested and expected. His work was efficient. To him is due a great deal of credit for the smooth management of the Meeting affairs.

In addition, the names of the Committee members are listed so that the guests at the Buffalo Meeting may know specifically the persons who were such gracious and satisfactory hosts.

Annual Meeting Local Committees

General Local Committee

M. E. Holmes, *Chairman;* S. F. Walton, *Vice-chairman;* G. J. Easter, *Secretary*

Finance Committee

Lyman D. Walrath, *Chairman;* W. J. Degenhart, Harloe S. Chaffee.

Transportation Committee

Donald E. Sharp, *Chairman;* M. R. Scott, Frank Lobee, William Horak.

Plant Trips Committee

R. C. Benner, *Chairman;* E. L. Lasier, H. L. Robson, M. R. Scott, O. I. Chormann, F. A. Lobee, Jr., J. P. Mulroy, J. C. Hostetter, K. W. Brownell, T. B. Fulton.

Ceramic Display Committee

M. E. Holmes, *Chairman;* W. T. Buckley, G. H. King, C. L. Sayre, J. P. Mulroy, F. M. Thormann, L. U. Milward.

Entertainment Committee

S. F. Walton, *Chairman;* F. Hazlewood, J. P. Mulroy, H. L. Robson, E. L. Lasier, L. D. Walrath, W. J. Degenhart, F. D. Bowman, Grover Lapp, E. W. Schramm, R. H. Pass, John Daniels, Jr., G. A. Hogatt, M. C. Gregory.

Coöperative and Meeting Service

G. S. Diamond, *Chairman;* M. H. Berns.

The entertainment committee for ladies was composed of wives of the committeemen.

COMMITTEE REPORTS

REPORT OF COMMITTEE ON RESEARCH*

Constant efforts to evaluate the functions of the American Ceramic Society have led to a study of the position of its Committee on Research. If it is true that the greatest single weakness of the Society is its relationship to business executives of the various ceramic arts and if we are to interest these executives, it becomes evident that the Committee on Research should be a practical working sales force of high potential value. If we further assume that the Society membership must extend its activities beyond the mere exchange of literature developed in these arts, we are confronted with problems in committee organization, personnel, and especially coöperative effort. As a whole, the Society is closer to the individualistic phases of empirical research than to its broadly applied basis or scientific aspects; this is a healthy condition only so long as the work of the Society can be sold. Failure to sell upon some intrinsic basis is simply the counterpart in the Society of conditions existing in industry, where organizations noted for large research expenditure and accomplishment are likewise noted for the employment of peculiarly aggressive technical men. Investigation in many corporations and establishments reveals adequate research expenditures in per cent of dollar sales only where the research workers plainly possess unusual ability to sell and execute ideas. We need not revert to the chicken and egg argument. The inference is plain. The Committee on Research wishes to review its position and, as the first step, reference is made to the following extract from the Constitution of the Society specifying the duties of the Committee on Research[1]:

(10) The Committee on Research shall consist of one member selected by each Division. Its duties shall be to organize and encourage scientific investigations pertaining to the ceramic and related industries, especially those investigations which will stimulate the development of our national industries and resources. It shall be empowered to coöperate with similar committees of other scientific societies and with government bureaus.

The functions of this Committee clearly overlap those of the Division research committees, a point that the writers of our Constitution must have realized when they inserted the following:

(14) The Coördinating Service Council shall consist of the General Secretary, Ex-Officio Chairman, and the Chairmen of the Committees on Research, Standards, Geological Surveys, Data, and Ceramic Education. The Council shall have general supervision of the work of these Committees, for the purpose of coördinating other organizations on ceramic topics and problems.

The founders provided that each Division should select a member for the Committee on Research, but in recent years the Chairman of each Division Committee automatically has become a member of the more general Committee on Research. The Society for some years has not availed itself of the provision for a service council. There is rooted deeply in many minds the idea that both of these committees are theoretical in character, that the Committee on Research will function only in and through a very active chairman and not because of impelling force of responsibility within the Committee. The excellent accomplishment of numerous Division research committees year after year has created a situation not unlike a declaration of states rights, and in reviewing the detail involved it is increasingly obvious that these Division committees should not in the least degree have their functions abridged. The Division Chairman is invariably an individual of marked ability, and he takes the committee job as seriously as he takes his daily work. It is unlikely that he will pass along, out of his committee into the hands of a general committee, some project in which his Division is greatly concerned; where coöperative effort is needed, these Division chairmen have made suitable, if not fully, adequate arrangements. It is unlikely further that busy men of this type could be required fairly to give additional time and energy to a general committee. The fact is, they have not done it, and today the Committee on Research is measurably a committee without portfolio. What was intended for bilateral activity has become unilateral. There is no confusion in answers to questions regarding Divisional activities; the current year committees have built up and put into motion some extremely valuable programs, and it is not until these are examined that a solution appears in the problem of the Committee on Research.

The Glass Division, for example, has held symposia on viscosity and on chemical durability. Sections of the Refractories Division have considered the rôle of crystallinity in refractories and are preparing to review the factors affecting rates of change in systems involving refractory compounds. With only rare exceptions, the subject matter of each item is sufficiently fundamental to suit the most exacting, but it is curiously evident that this subject matter is seldom fully fundamental. Here arises probably the only single clear fact in the whole structure, which may be stated by saying that the original conception of the program just impinges on the purely scientific field. It has been stated, with more truth perhaps than grace, "that the most reliable fundamental data available to the American Ceramic Society have been obtained, not through the industries most concerned, but from the Geophysical Laboratory, a foundation dedicated to geological study."

What means, then, have we at hand to proceed with studies of equal merit in the fields of viscosity, catalysis, colloids, or thermochemistry? Is there not a point beyond which the Division committees may not care to go? A study of the rôle of water-hardness in ceramic operations conceivably might yield some practical returns in a Division study, but its final solution is deep in the fog of silicate chemistry. By the very nature of their constitution, the Division committees have reached and will continue to reach a limit, varying in its extent by differences in the ability of individuals making up the com-

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* Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Buffalo, N. Y., 1935. Received February 7, 1935.

[1] *Bull. Amer. Ceram. Soc.*, **7** [4], 101 (1928).

mittees. Such a committee may be ideal, and usually is, from the working side of the art, but it may fall far short of attaining sustained action when the problem goes into pure science. The keenest type of commercial organization is that one in which demarcations in ability are recognized and employed. Here in the case of the Society no consistent effort has been made to classify ability or to use it with real ultimate discretion.

The Committee on Research should be changed in its set-up and probably reduced in size. It should be constituted for not less than three-year periods, or preferably with three-year memberships on a stagger basis. It should be made up of men whose age and aptitude fit them for real coöperative and promotional work in pure science. A committee thus assembled could take over a given problem, either upon the apparent exhaustion of that problem in the Division or by request of the Division. The problem need not be one affecting all Divisions. It is safe to assume that such a committee, by publicity work alone, could become a powerfully vital organization. An analysis of ceramic ills would seem to indicate that we suffer more because of failure to state our problems than by actual failure to accomplish results in research; our appraisals frequently do not get below the surface. It would be practical for the Divisions involved to continue their work on a given subject and simultaneously to have the Committee on Research go forward in an effort to solve the deeper scientific aspects of the case. Duplication of work would be unlikely or it might be deemed advisable. Such a committee needs no administrative functions. The present Divisional and secretarial activities, involving program material, symposia, and publication are well organized and managed. We have failed in the great field that lies beyond these activities. In recent years the Trustees have taken their duties seriously and, with rare exceptions, all Division officers have established excellent records of performances. It should be a simple matter to set up the Committee on Research in a way calculated to suggest and correlate the work in broad fundamentals. Such a committee could be given definite assignments under a plan embracing the joint action of Trustees, Division Chairmen, and Fellows, the Committee to be selected by the Fellows. There could be no rational objections to the development of such a committee in the Fellowship, where there may be need for specific activities and where the work done could not be burdened with Divisional routine and isolation of interest. After selecting one of these methods of procedure or some better plan, growing out of the discussions incident to the change, the problem of the coördinating Service Council should be taken up for disposition. This Council could not be other than clumsy in its operation and without complete sense of direction.

The suggestions in this report seek to crystallize the thoughts of many earnest members of the Society, whose expressions have varied through an extraordinarily wide range of opinion, largely confined to the elements of need and the present inefficient system. Individual aims and attainment in these arts must suffer as long as we retard our growth in fundamental ceramic knowledge.

—J. M. McKinley, *Chairman*

REPORT OF THE REFRACTORIES DIVISION RULES COMMITTEE*

I. Parent Society rules governing handling of papers which were worked out at the Annual Meeting at Pittsburgh in 1933 and which have been accepted by the Society and are published in *The Bulletin*, April, 1933, page 102, are entirely workable and need no further change. It appears to us that it is now a case of seeing that everyone lives up to these rules instead of again revising the rules.

II. The present status of the By-Laws of the Refractories Division is as follows:

After six years of effort, definite By-Laws were accepted by the Refractories Division and are published in *The Bulletin*, March, 1928, page 62.

In 1929, these By-Laws were modified slightly. The changes were accepted by the Refractories Division and appear in *The Bulletin*, April, 1930, page 122. Corrections of these rules were published in *The Bulletin*, May, 1930, bottom of page 164.

III. We recommend the following changes in the By-Laws of the Refractories Division at this time:

Section (4) Elections: Subhead (*b*) Nominating Committee; line 1, change "same session" to "same time."

Line 10, change "Executive Committee" to "Secretary-Treasurer."

Line 11, change "the Division Secretary-Treasurer" to "he."

Line 13, change "once" to "90 days."

Line 15, change "chairman" to "Secretary-Treasurer."

Line 16, change "any time before actual voting for the office designated begins" to "at least 60 days before the start of the Annual Meeting."

Following line 16 add:

"The actual voting shall be by letter ballot, conducted by the General Secretary of the Society, on being supplied with the names by the Divisional Secretary."

The object of the above change is to elect the Divisional officers before the Annual Meeting.

Section (6) Standing Committees, Section (*b*), change lines 3 and 4 to:

"Committee on Standards, Group on Standardization of Tests."

"Committee on Standards, Group on Standardization of Products."

(Combined into one Divisional Committee of two members.)

The member of longest standing on the Committee shall be its Chairman and shall report to both committees of the parent Society. If both are of equal standing, the chairmanship shall be determined by drawing lots.

IV. We further recommend that next year's Divisional Rules Committee be instructed to prepare an exact set of the complete By-Laws of the Refractories Division as they stand at the end of the Buffalo Meeting and submit them to the General Secretary's office for early publication in *The Bulletin*.—D. W. Ross, *Chairman*

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., February, 1935 (Refractories Division). Received February 7, 1935.

SUPPLEMENTAL REPORT OF THE COMMITTEE ON GEOLOGICAL SURVEYS*

The Committee submits the following information regarding the work done by state, federal, and educational institutions, which was received too late to include in the main report published in the February *Bulletin:*

Alabama

The Southern Experiment Station of the U. S. Bureau of Mines, University of Alabama, is doing a considerable amount of work on the beneficiation of kyanite.

The University of Alabama, coöperating with the U. S. Geological Survey, is making an investigation of the clays of Alabama and Tennessee. G. R. Mansfield, of the U. S. Geological Survey was in direct charge of this work. This was referred to under "U. S. Geological Survey" in our first report (see February *Bulletin*, p. 77).

Georgia

The Division of Geology of the Department of Forestry and Geological Development, in coöperation with the U. S. Geological Survey and the Division of Geology of the Georgia Fish and Game Division, made an investigation of the kyanite deposits of Georgia; $2000 of Public Works funds were made available for this investigation. The printed report will appear in *Bulletin* No. 46 of the Georgia Geological Survey early in 1935.

The Georgia Geological Survey also has published an *Information Circular* on kyanite, vermiculite, and olivine deposits of Georgia. The above work was referred to in the original report.

The Department of Ceramics, Georgia School of Technology, Atlanta, Ga., carried on ceramic research during 1934, somewhat related to geological occurrence and beneficiation. About $1000 was expended on this work.

North Carolina

The Ceramic Engineering Department, University of North Carolina, is making an investigation of the commercial value of North Carolina olivines and is investigating the action of various bonds for the purpose of producing olivine refractories. This work is expected to continue until June, 1935.

About $500 was expended in the investigation of North Carolina raw materials during 1934, and approximately the same amount will be expended during 1935.

Early in 1934 the University of North Carolina issued *Bulletin* No. 6 of the Engineering Experiment Station, "The Occurrences, Properties, and Uses of Commercial Shales and Clays of North Carolina," by A. F. Greaves-Walker, N. H. Stolte, and W. L. Fabianic.

South Carolina

Stephen Taber, state geologist, South Carolina Geological Survey, has been making a study of certain deposits of clean quartz sand in the vicinity of Columbia and of methods of removing traces of iron from this sand to make it suitable for use in the manufacture of higher grades of glass.

Tennessee

The Division of Geology, Department of Education, Nashville, Tenn., has been continuing studies of clays and shales of Tennessee, noting the geology associations and making physical tests.

The Tennessee Valley Authority, Knoxville, Tenn., has, on its program of research to be taken up in the near future, the standardization and utilization of southern feldspar, kaolin, ball clay, etc. The present research program is chiefly research on the designing and operation of electric furnaces.

Virginia

In 1934 the Virginia Geological Survey published *Bulletin* No. 42, "Geologic Map of the Appalachian Valley of Virginia with Explanatory Text." This geologic map contains much basic information pertaining to the distribution and structure of formations in Virginia west of the Blue Ridge, which should be of considerable value to the ceramic industry.

During 1934 the Ceramic Engineering Department of the Virginia Polytechnic Institute continued a study of ceramic raw materials of the state of Virginia. This work will be continued through 1935 and 1936.

West Virginia

The State Geological Survey has planned a comprehensive study and report on the ceramic materials in West Virginia for 1935. This will be in coöperation with W. A. Koehler, Ceramic Department, West Virginia University.

The Ceramic Department of West Virginia University hopes to complete its investigation on West Virginia clays, begun several years ago, due to help made available by the FERA.

New Jersey

Work of a geological character was carried on by the Department of Ceramics of Rutgers University, New Brunswick, N. J., as follows:

The investigation of the shales of New Jersey includes field surveys and tests in the laboratory on sixty-five samples collected from various deposits in the State. This project has been financed jointly by the Department of Ceramics and the Emergency Relief Administration of New Jersey. About $1000 was expended in 1934, and the work will be practically completed by March 1, 1935, at a total expenditure of $1500. A bulletin, covering the results of this work, will be issued by the Department of Ceramics. An abstract of the work will be available for publication in the *Bulletin of the American Ceramic Society.*

A survey of the clay resources of the state of New Jersey will be carried out during 1935 at a cost of $2500 if funds are made available by the ERA.

Committee on Geological Surveys: W. M. WEIGEL, *Chairman*, J. E. LAMAR, H. RIES, J. W. WHITTEMORE, and HEWITT WILSON.

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* For the first part of this report see *The Bulletin*, February, 1935, Program issue, pp. 75–77.

Received February 15, 1935.

AMERICAN CERAMIC SOCIETY PROPOSED CHANGES IN THE CONSTITUTION AND BY-LAWS*

Article II

Membership

Change paragraph (8) to read as follows:

* For the latest publication of the entire Constitution see *Bull. Amer. Ceram. Soc.*, **10** [7], 245–57 (1931). Amendments to the Constitution may be found in the following *Bulletin* references: March, 1932, p. 74; December, 1932, pp. 271–73; January, 1933, pp. 27–28; April, 1933, pp. 100–104; June, 1933, pp. 201–202.

Life Members are those who have made a single payment of an endowment fee as prescribed in paragraph (4), Article III. Life Members will enjoy the same rights and privileges as Active Members.

Delete paragraphs (13) and (14).

After paragraph (12) add the following:

(13) Student Members shall be those who are students in schools and colleges and such student membership may be retained until the end of the year following that in which the Student Member ceases to be an enrolled student. The grade of Student Member will automatically be changed to Associate Member one year after the Student Member leaves school.

(14) All Honorary Members, Ex-Officio Honorary Members, Fellows, Active Members, Life Members, Associate Members, Corporation Members, Life Corporation Members, Industrial Association Members, and Student Members shall be equally entitled to the privileges of membership, except that only Fellows, Active Members, Life Members, one representative of each Corporation Member, and one representative of each Life Corporation Member shall be entitled to vote. Such representative shall be officially designated by the person, firm, or corporation represented. Only Fellows, Active Members, and Life Members shall be entitled to hold office. The Roster of each grade of membership shall be printed separately in at least one publication issued by the Society annually.

(15) Any person may be expelled from any grade of membership of the Society if written charges, signed by five or more Fellows, Active Members, or Life Members be filed against him or her, and if said charges are considered and acted upon as set forth in Article VII, Section (3). In case of such expulsion any moneys paid the Society as endowment fees become forfeit to the Society and automatically become a part of the Research Fund.

Article III

Dues

Add the following paragraph to this article:

(8) Student Members shall pay annual dues of $5.00.

A MEMORIAL TO CHARTER MEMBERS WHO PASSED AWAY THIS YEAR*

By Willard D. Richardson

A year ago a gracious compliment was bestowed upon the surviving Charter Members—a handsome framed certificate of Life Membership in the Society. There were then ten of us, six of whom were present at Cincinnati. The number has been reduced to eight by the death of Dr. Binns on December 2, 1934, at the age of seventy-seven, and of W. D. Gates on January 28, 1935, at the age of eighty-two. These men were both very dear to the older members of our Society and Dr. Binns also to generations of students of the New York State School of Ceramics.

It is fitting that we pause to commemorate the character and service of these two old and beloved members who have passed from us.

Charles Fergus Binns, by his books and numerous published papers and through his years of work at Alfred, was a foremost teacher of ceramics. What higher encomium can be given a man than that he was a great teacher? The need of the world today is a better, more widespread knowledge, not only of the arts and sciences but of how to live and how to act intelligently, wisely, and humanely. In brief, we need today in every industry and in every walk of life more teachers of the noble character and broad culture and scientific and artistic attainments of Charles Fergus Binns.

Though I never had the privilege of the artistic and technical education in ceramics that Dr. Binns gave his students, I was many times favored by his kind and courteous answers to my requests for information. At our earlier meetings, our Society often visited art galleries and inspected pottery exhibits. On such occasions I always kept close to Dr. Binns that I might have the benefit of his comments and his answers to my questions.

William D. Gates was about the first clayworker who attracted my attention. One day, in 1885, I went into the reading room of the Minneapolis Builders Exchange and picked up an early number of the *Clay-Worker*, in which I read an account of a meeting of the Illinois Clayworkers Association and an address by William D. Gates, in which he told how he first became interested in clay. He was practicing law in Chicago. He had acquired a tract of land a few miles from the city. His inquisitive mind found under the soil a bed of clay. He dug into it and took out a handful which he kneaded into a ball and from this clay he formed a trinket which, after having been fired in a pottery kiln, he wore on his watch chain for many years as a souvenir. He also discovered on this visit to his land that there was a great need of drainage in that section. So he took up the study of tile drainage and tile making with the result that he built a drain tile factory and undertook the promotion of farm drainage in that part of the State. A railroad station was established near his tile plant and I remember having seen a picture of the depot Gates built entirely of drain tile, a unique and artistic structure.

As I had incidentally become interested in clay about the same time, I at once experienced a fellowship with

* Presented at the Annual Meeting, American Ceramic Society, Buffalo, N. Y., Tuesday evening, February 19, 1935.

Gates even before I ever saw him. In October, 1887, I attended the Second Annual Convention of the National Brick Manufacturers Association at Chicago where I first met Gates, a charter member of the N. B. M. A. and at that time a manufacturer of architectural terra cotta.

In 1892 I built a house of high-grade pressed brick. The mantel in the reception hall was entirely of brick from floor to ceiling. I wanted an ornamental piece of terra cotta midway between the shelf and the ceiling. I wrote to Gates about it and he sent me a picture of what he could furnish, stating that if it would answer my purpose it would be shipped to me on the terms, "You pay the freight, we do the rest." This kindness was characteristic of the man. When he later went into the manufacture of pottery and had developed something new in glaze he would send me a vase, stating that he wanted me to have a sample of his latest work. When he had published his "Button-Hole Talks" he presented the handsome book to his friends, with an autographed notation on the flyleaf. We prize this little book highly as a memento of Gates' versatility, his rare gift of expression, his fascinating style, his delightful imagery, and his philosophy of life. The talks are mostly represented in the words of those who button-holed him in his travels and on his vacations.

It is a satisfaction to know that Binns and Gates were spared to bring their chosen life-work to such completion Their influence does not end with their deaths. Their lives contain many useful and noble lessons that will continue to inspire others traveling along paths of like endeavor. Bacon said, "A man dies as often as he loses a friend." The sad thing about this to us old fellows is that we so rarely form new friendships, and hence we feel such losses more keenly.

We mourn the passing of our dear Charter Members, Charles Fergus Binns and William Day Gates, but we will keep the faith and march on, and, as Thoreau expressed it, "live our life, do our work, take our hat."

RESOLUTION IN MEMORY OF CHARLES F. BINNS

The Fellows and members of the American Ceramic Society record with profound sorrow the loss of our co-fellow, Dr. Charles Fergus Binns, whose death occurred December 4, 1934, at his home in Alfred, New York.

To those associated with him in teaching, in craft, or in technical organization, Dr. Binns inspired confidence and devotion, and his passing has left a vacancy which we cannot hope to fill. We must console ourselves with the memories of his life among us and the inspiration he has left us to carry on his work.

WHEREAS, by the death of Charles Fergus Binns, who passed to his eternal reward on December fourth, 1934, the Fellows of the American Ceramic Society have lost one of their Charter Members and beloved leaders, and

WHEREAS, the world of ceramic education has lost one of its pioneers and great men, and

WHEREAS, we are aware of his true greatness, of his constant loyalty to truth, his genius as a master craftsman, and his constant devotion to duty, and

WHEREAS, the members of the Fellowship of the American Ceramic Society wish to express their deep sense of personal grief and loss at his passing,

THEREFORE, BE IT RESOLVED, that we, the Fellows and members of the American Ceramic Society, pause at this time to remember his many services and to express our sorrow that his presence will be denied us, and

That we extend to the members of his family our heartfelt sympathy.—G. A. BOLE, *Chairman*, M. E. HOLMES, A. I. ANDREWS, S. G. BURT

RESOLUTIONS IN MEMORY OF WILLIAM D. GATES

The passing from us of William D. Gates, at the age of 82, should be given more than casual notice by the members and Fellows of the American Ceramic Society. It is given to few men to enjoy so many years of active interest and devotion to the technique and artistry of his chosen life work. As we older members contemplate the life of Gates and of those who have gone before him we are impressed with the wisdom and judgment of Orton in selecting for Charter Members men of high personal character as well as of notable achievement in ceramic technology.

We feel that it was a liberal education to have been associated so intimately with these men as was the privilege of those of us who were active in the organization during the years of its small membership. We came to know these men intimately and to love them for their qualities of mind and heart and their genial good fellowship, to admire their abilities, and to appreciate the technical information they so generously imparted. Our meetings, annually and semi-annually, were an inspiration for better work throughout the year.

Gates had completed his life work, so his death cannot be said to be a loss to the ceramic industries, though it leave an aching void in the minds and hearts of his friends. All who knew him will ever cherish the memory of his noble qualities, his kind and genial disposition, his magnetic personality, his keen appreciation of the true, the beautiful, and the humorous, his contributions to the amenities of social intercourse during the many years of his active participation in the meetings of the N. B. M. A., of which he was also a charter member, and of the American Ceramic Society, his rare gift of expression, the word pictures presented in his original, inimitable "Button-Hole Talks" and in his after-dinner speeches. "We ne'er shall see his like again," must be the sentiment of all who had the privilege and pleasure of knowing him intimately.

It is eminently fitting that the American Ceramic Society make public recognition and permanent record of its high esteem of William D. Gates as a man and fellow-worker in promoting the aims and purposes of this organization and that this testimony be given his family, together with our sympathy in their bereavement.—W. D. RICHARDSON, ADOLPH HOTTINGER, R. T. STULL, AND R. K. HURSH, *Committee*.

NECROLOGY

Charles Shepard Reed

Charles Shepard Reed, President of the Chicago Retort and Fire Brick Co., for many years a corporation member of the American Ceramic Society, died on February 5, 1935, at his home in Chicago, Illinois.

He was born in Montpelier, Vermont, June 4, 1868, and received his later education at the Chicago School of Manual Training.

In 1888 he started with the Chicago Retort and Fire Brick Company, and one year later was elected Secretary of this company.

In 1907 he was made President of the company and held this position at his death. Since 1928 he had also been connected with the Universal Locomotive Arch Company in the capacity of vice-president.

His widow and a son, Charles Shepard Reed, Jr., survive him.

NEW MEMBERS

CORPORATION

American Sheet & Tin Plate Co., J. C. Eckel, Assistant General Manager (voter), 902 Frick Bldg., Pittsburgh, Pa.
Celo Mines, Inc., V. L. Mattson (voter), Burnsville, N. C.
Quigley Company, Inc., W. S. Quigley, President (voter), 56 W. 45th St., New York, N. Y.

PERSONAL

Allen, John, 103 Broxholm Rd., High View Park, W. Norwood, London, S. E. 27, England.
Barger, H. D., Bay Village, Ohio.
Bowman, Ralph McLane, Market St., Youngstown, Ohio; purchasing agent, Republic Steel Corp.
Boyce, Robert E., East Liverpool, Ohio; manager, Harker Pottery Co., Chester, W. Va.
Christian, W. T., Ironton, Ohio; superintendent, The Ironton Fire Brick Co.
Clingan, J. R. T., Niles Fire Brick Co., Niles, Ohio.
Eidures, Julys, Latvian University, Kronvalda, Culv. 4, Riga, Latvia.
Elliott, A. W., 2063 E. Gage Ave., Huntington Park, Calif.; executive.
Emerson, Walter H., Elysian Way, East Liverpool, Ohio; Homer Laughlin China Co.
Fay, Gordon C., 301 W. Pine St., Clearfield, Pa.; Harbison-Walker Refractories Co.
Flu, Eldon Bruce, 1533 Crooks Rd., Royal Oak, Mich.; Champion Spark Plug Co.
Hayes, J. A., Lt. Commander, Naval Boiler Lab., U. S. Navy Yard, Philadelphia, Pa.
Lloyd, Frank L., 2112 Mt. Halley St., Baltimore, Md.; mechanical engineer, Crown Cork & Seal Co.
Maddux, O. L., Hamilton, Ont., Canada; United Gas & Fuel Co.
McCreery, George L., 394 E. Tuscarawas Ave., Barberton, Ohio; technical superintendent, The Ohio Insulator Co. Division, The Ohio Brass Co.
Moriarty, Wilson H., 10,600 Quincy Ave., Cleveland, Ohio; sales engineer, National Malleable and Steel Castings Co.
Offutt, James S., 880 East Broad St., Columbus, Ohio; industrial salesman, U. S. Gypsum Co.
Robinson, Mayes R., 409 Arden Rd., Pittsburgh, Pa.; industrial engineer.
Rudisill, William A., 229 Chapman Place, Elmira, N. Y.; chief chemist, Thatcher Mfg. Co.
Shaw, Lucian, West Lafayette, Ohio; enameler, The Moore Enameling & Mfg. Co.
Sheehan, P. J., Niles Fire Brick Co., Niles, Ohio.
Shiner, J. B., Corning Glass Works, Corning, N. Y.
Skeoch, Walter K., 2149 Bay St., Los Angeles, Calif.; sales manager and research, Pacific Coast Talc Co.
Steenrod, Lewis McC., Wheeling Steel Corp., Wheeling, W. Va.
Thomas, J. H., 141 W. Locust St., Newark, Ohio; Research and Industrial Materials Division, Owens-Illinois Glass Co.
Turnbull, Gale, Sebring Pottery Co., Sebring, Ohio; designer and art director.
White, Harold I., 4624 Royal Ave., Niagara Falls, N. Y., research metallurgist, Union Carbide & Carbon Research Laboratories, Inc.
Whitmer, C. H., Cambridge-Wheatley Co., Box 836, Cincinnati, Ohio.
Yanovsky, Alexander, 92 Hoy Ave., Fords, N. J.; ceramic engineer, General Ceramics Co.
Zimmer, Harry, Porzellanfabrik, Waldershof, Oberpfalz, Germany (temporary address until June 1, 1625 Wood St., Wheeling, W. Va.)

STUDENTS

Hamburger, Herbert M., Univ. of North Carolina, Raleigh, N. C.
King, John Utley, Jr., Univ. of North Carolina, Raleigh, N. C.
Jordan, Suzanne, Ohio State Univ., Columbus, Ohio.
Lloyd, Arthur Shelton, Univ. of North Carolina, Raleigh, N. C.
Martin, William R., Univ. of North Carolina, Raleigh, N. C.
Oldham, Robert T., New York State College of Ceramics, Alfred, N. Y.
Raine, F. F., Iowa State College, Ames, Iowa.
Reimer, John J., New York State College of Ceramics, Alfred, N. Y.
Roberts, John T., Iowa State College, Ames, Iowa.
Sauls, J. Beverly, Univ. of North Carolina, Raleigh, N. C.
Young, David H., Georgia School of Technology, Atlanta, Ga.

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Walter Steger	1		—
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Office	9		
	—		
	30	Grand Total	44

Message from Hotel Statler Representative

COLONEL ROSS C. PURDY:

During the period that your Meeting was here I talked with many of our employees and department heads as well as various concessionaires. All spoke in the same manner that your Annual Meeting was one of the best they ever had occasion to serve in our twelve years in Buffalo.

Your advance reservations and final registration seemed to give an endorsement not only of Buffalo as a convention city for your Society, but also of the promotional efforts put forth by yourself and your local members to make this Meeting as successful as it was.

—JOHN DANIELS, JR., *Sales-Representative, Hotel Statler*

ROSTER CHANGES DURING FEBRUARY

Corporation

Certain-teed Products Corp., H. H. Van Hagan (voter), Beaver and Military Rds., Buffalo, N. Y. (100 E. 42nd St., New York, N. Y.)
Riddell Co., W. A., L. Haigh (voter), Bucyrus, Ohio. (W. A. Riddell, voter).
Rundle Mfg. Co., H. J. Held (voter), Milwaukee, Wis. (A. C. Held, voter).

Personal

Albery, D. F., 1750 Wrightwood Ave., Chicago, Ill. (2525 Clybourn Ave., Chicago.)
Ault, Alfred S., 5314 Grayton Rd., Detroit, Mich.(Wesleyville, Pa.)
Blaha, Emil, 74 Hoy Ave., Fords, N. J. (Metuchen, N. J.)
Boehler, Joseph, 781 Ashland Ave., St. Paul, Minn. (Chicago, Ill.)
Campbell, A. R., 76 Rose St., Metuchen, N. J. (875 Middlesex Ave., Metuchen.)
Corson, Kenneth P., Taylor, Wash. (Seattle, Wash.)
Duncombe, George H., Jr., 150 E. Frambes Ave., Columbus, Ohio. (Urichsville, Ohio.)
Farren, Mabel C., 4416 Mettler St., Los Angeles, Calif. (Lee Apts., Los Angeles.)
Fisk, Henry G., 4614 Johnson St., Gary, Ind. (Gary.)
Hardy, R. G., Coffeeville, Kans.(New Lexington, Ohio.)
Hayes, Walter B., Davidson Enamel Products, Inc., Clyde, Ohio. (Connersville, Ind.)
Ockerman, Elmer H., 120 S. Wetherly Dr., Beverly Hills, Calif. (Los Angeles.)
Purcell, Burnette, 1750 Wrightwood Ave., Chicago, Ill. (St. Louis, Mo.)
Robinson, Richard E., Lincoln St., Bolivar, Pa. (State College, Pa.)
Royal, Herbert F., 960 Mohegan Ave., Birmingham, Mich. (1047 Madison Ave., Birmingham.)
Smith, Roy G., Ft. Worth Club, Fort Worth, Texas. (Acme Brick Co., Fort Worth.)
Terry, G. E., 527 Highland Ave., S. W., Warren, Ohio. (Columbus, Ohio.)
Trees, Jack E., 1130 Holcomb St., Apt. 42, Detroit, Mich. (Anderson, Ind.)
Williams, Arthur E., 1004 Nevada St., Urbana, Ill. (Dubuque, Iowa.)

California Section

The first meeting of the year of the California Section was held at the University of Southern California, Monday, February 11, with an attendance of forty-three.

The program was arranged by Dean A. C. Weatherhead, the hit of the evening being a speech in dialect by Professor Baldwin of the Department of Architecture.

Glen Lukens of the Ceramics Department offered an eloquent plea for an appreciation of the possibilities of a study of design as a means of increasing the eye value of ceramic products. Mr. Lukens presented a clear and logical analysis of the possibilities open to the ceramic industry and pointedly indicated that there is an obligation on the part of ceramic manufacturers to emulate the example set forth by manufacturers of motor cars, radios, refrigerators, etc.

Dean Weatherhead outlined the plans of the College of Architecture and Fine Arts with respect to the building of a consciousness of ceramics in the student body as a whole, pointing out the fact that astonishingly few of the young people on the campus realize the meaning of the term.

Thomas S. Curtis reviewed the program of the course in Ceramic Technology during the past term and presented the schedule for the work of the second term to start late in March.—T. S. Curtis, *Secretary*

Central Ohio Section Meets

G. W. Morey, of the Geophysical Laboratory, Washington, D. C., was speaker at the meeting of the Central Ohio Section held December 19 at Ohio State University, Columbus, Ohio. His subject was "Chemical Interpretation of Volcanic Action."

R. Bradfield was the speaker at the meeting held January 8 at Battelle Memorial Institute, Columbus, Ohio. His subject was "Mechanics of Moisture Movement through Soil."

Both meetings were well attended, and the newly organized Section has additional program features for the remainder of 1935.—Chester R. Austin, *Secretary.*

St. Louis Section Elects Officers for 1935

More than thirty-two members and visitors attended the dinner and meeting of the St. Louis Section of the American Ceramic Society held January 3, at Dietz Little Bevo.

Officers for 1935 were as follows: Joe Wright, *Chairman;* H. W. Weber, *Vice-Chairman;* Mr. Perry, *Treasurer;* and J. L. Crawford, *Secretary.*

C. M. Dodd of the Missouri School of Mines, Rolla, Mo., invited the members of the Local Section to attend Engineer's Day at Rolla this spring. A special program will be arranged. Further particulars will be announced later.

W. L. Fabianic of the Owens-Illinois Glass Co., Alton, Ill., gave a talk on the methods used in petrographic analysis and also described the use of the microscope for analysis of grain size. It was decided that petrographic analysis offers one of the most valuable means of analyzing refractories yet discovered.—H. W. Weber, *Vice-Chairman*

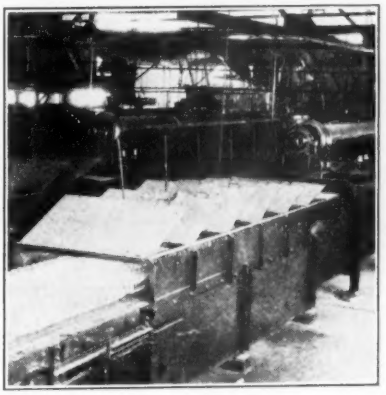
MONTANA CLAY PRODUCTS MANUFACTURERS TECHNICAL MEETING

Members Will Organize Local Section

The clay products manufacturers of Montana will hold a technical meeting at the Montana School of Mines in Butte during the last week in March. At this meeting the manufacturers under the chairmanship of W. W. Kriegel plan to organize a Local Section of the American Ceramic Society. The membership list will include persons in Montana, North Dakota, South Dakota, Wyoming, and eastern Washington.

Hewitt Wilson, director of the Department of Ceramics at the University of Washington and Secretary of the Pacific-Northwest Local Section, will be a speaker at this meeting.—W. W. Kreigel

Solvinex



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Goggles
Willson Products, Inc.

Gold
Ceramic Color & Chemical Mfg. Co.
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The Hommel Co., O., Inc.
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Grinding Wheels
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(*Carbofrax* heat treating)
Norton Co. (*Crystolon*)

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Norton Co.

Iron (Enameling)
American Rolling Mill Co.

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Drakenfeld & Co., B. F.
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The Exolon Co.
Jungmann & Co., Inc.
Norton Co.

Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
Hammill & Gillespie, Inc.
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Manganese
Ceramic Color & Chemical Mfg. Co.
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The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

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Carborundum Co. (*Carbofrax*)
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Denver Fire Clay Co.
Ferro Enamel Corp.
Norton Co.
Pittsburgh Plate Glass Co.

Mullite (Artificial)
The Exolon Co.

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The Hommel Co., O., Inc.

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The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
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Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

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The Hommel Co., O., Inc.
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Titanium Alloy Mfg. Co.
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Norton Co.
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The Hommel Co., O., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

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Silicon Carbide Firesand
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Denver Fire Clay Co.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
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Sodium Antimonate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Sodium Fluoride
Denver Fire Clay Co.
Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
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Sodium Silica Fluoride
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The Hommel Co., O., Inc.

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Metal & Thermit Corp.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.

Titanium
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Drakenfeld & Co., B. F.
The Hommel Co., O., Inc.
Titanium Alloy Mfg. Co.
The Vitro Mfg. Co.

Titanium Oxide
Drakenfeld & Co., B. F.
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The Roessler & Hasslacher Chemical Co.
Titanium Alloy Mfg. Co.
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ALPHABETICAL LIST OF ADVERTISERS

	Page
Allied Engineering Co.	14
American Potash & Chemical Corp.	15
American Telephone and Telegraph Co.	16
Bausch & Lomb Optical Co.	4
Bonnot Co.	3
Buyers' Guide	8
Ceramic Color & Chemical Mfg. Co.	15
Chicago Vitreous Enamel Product Co.	7
Consolidated Feldspar Co.	11
Denver Fire Clay Co.	4
Du Pont de Nemours, E. I., & Co.	Inside Front Cover
Edgar Bros. Co.	2
Edgar Plastic Kaolin Co.	2
Ferro Enamel Corp.	3
Hammill & Gillespie, Inc.	7
Hartford-Empire Co.	14
Journal Society of Glass Technology	6
Jungmann & Co., Inc.	15
Kentucky-Tennessee Clay Co.	13
McDanel Refractory Porcelain Co.	15
Metal & Thermit Corp.	Outside Back Cover
Norton Co.	12
Pacific Coast Borax Co.	6
Paper Makers Importing Co.	7
Pittsburgh Plate Glass Co.	13
Porcelain Enamel & Mfg. Co.	2
Potters Supply Co.	14
Professional Directory	6, 10
Roessler & Hasslacher Chem. Co.	Inside Front Cover
Simplex Engineering Co.	5
Simpson Foundry & Engineering Co.	2
Spinks, H. C., Clay Co.	Inside Back Cover
Standard Pyrometric Cone Co.	3
Tables Annuelles de Constantes	13
Vitro Mfg. Co.	3
Willson Products, Inc.	10
Wilson, H. W., Co.	6

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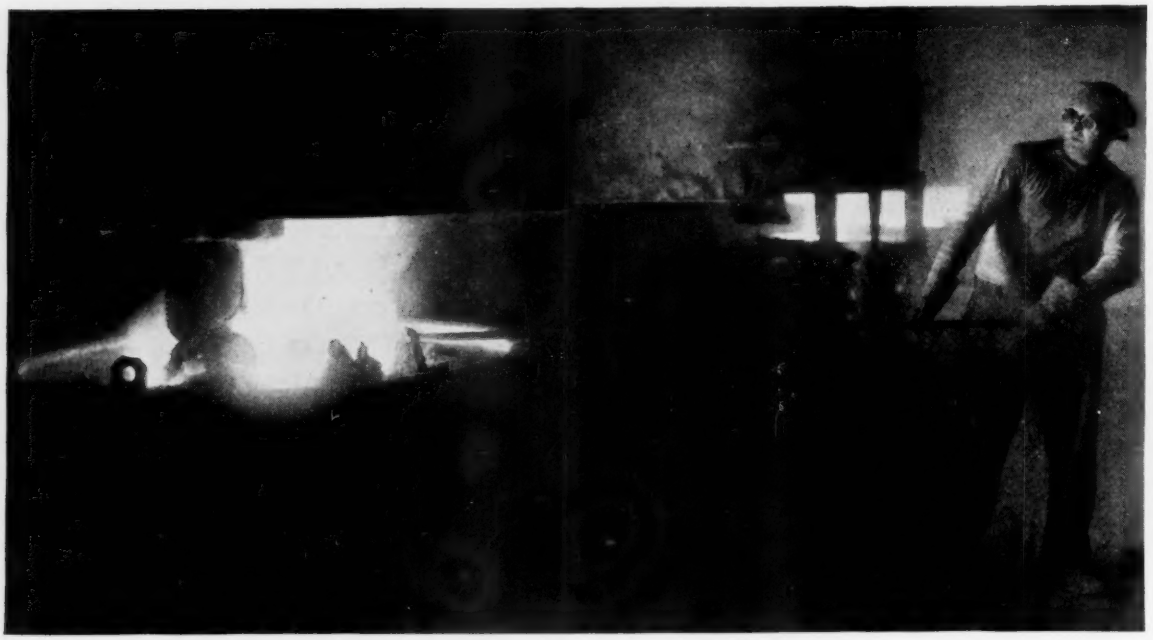

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Clay, Vallendar
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Lead Chromate
Magnesium Carbonate
Manganese Dioxide
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Neodymium Oxalate
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Nickel Oxide, Gray
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Potassium Bichromate
Potassium Nitrate
Potassium Permanganate
Powder Blue
Rutile, Powdered
Selenium
Sodium Antimonate
Sodium Bichromate
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